Sugar Bush Management for Maple Syrup Producers

Revised June, 1987

by

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Forest Resources Branch

Ontario Ministry of Natural Resources

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Note: The units of measurement in this publication have been converted to the metric system as adopted for use in Canada. Some rounding of metric figures has been carried out where feasible.

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Below: Maple Syrup time circa 1899.

Introduction

Indians making maple sugar.
Photo by: Public Archives of Canada.

Maple syrup and sugar were among the earliest agricultural crops produced in Ontario. Production of them is a unique part of our agricultural heritage.

The technique of maple sugar making was discovered by the Indians. Many legends relate to its discovery. In the spring of the year the Indians would move from their winter hunting grounds to set up camp in the sugar bush. They tapped trees by gashing them with a tomahawk in a slanting direction and then inserted a wooden chip or spout to carry the sap drop by drop into a birch bark receptacle resting on the ground.

The sap was boiled in earthenware pots or in green birch bark buckets over hot coals. Another method of boiling was to drop red hot stones into the sap contained in hollowed troughs. The maple sugar they produced was highly prized by them since it was the only sugar available.

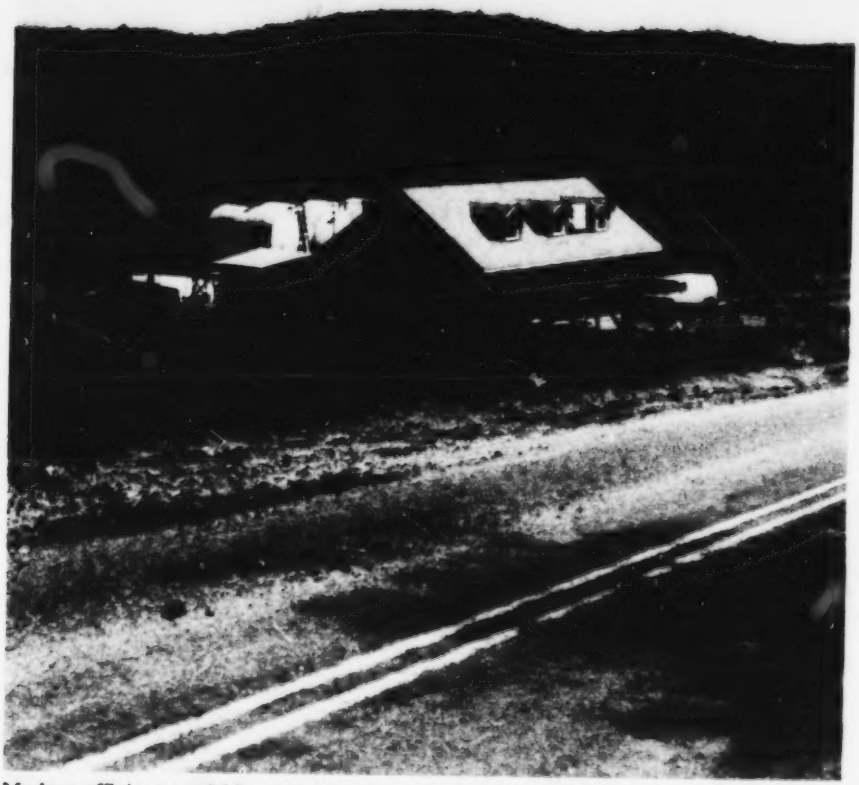
With the coming of the fur traders and settlers, the Indians obtained iron or copper kettles and axes and made sugar in a manner similar to that of the early settlers.

In Ontario four species of maple trees are tapped. They are as follows: the sugar maple, *Acer saccharum* Marsh; the black maple, *Acer nigrum* Michx.f.; the red maple, *Acer rubrum* L. and the silver maple, *Acer saccharinum* L. However, the sugar maple is the only one tapped on a commercial basis. It is a high yielding sap producer found extensively throughout southern Ontario and parts of northern Ontario. Black maple which is found in the extreme southern portions of the province is also a high yielding sap producer, but its occurrence in sugar bushes is much more limited than sugar maple.

The sugar bush management practices discussed in this publication make specific reference to sugar maple but apply also to black maple since the two species are very closely related.

The red and silver maple species are sometimes tapped, but they are less productive than sugar and black maple.

For many years the reduction in the number of farms and the com-



Modern efficient roadside sugar camps are replacing the older bush camps. Increased production and improved quality of maple products are important objectives of Ontario's maple industry.

plete specialization of many farmers led to a significant decline in maple production. This decline in production has resulted in record prices for maple products in recent years.

During the past two decades increasing prices combined with modern technology and equipment have provided farmers with the means to produce maple products in harmony with today's economic and labour problems. Hence the annual production of maple products has been relatively stable with between 908,000 and 1,362,000 litres (200,000 and 300,000 gallons) of pure maple syrup and 9,000 – 11,000 kilograms (20,000 – 25,000 pounds) of maple sugar being produced.

In order that the present production of maple products will continue and expand, cost of production must be minimized, while at the same time high quality maple products must be produced.

Taphole Yield Factor

Sugar bush productivity can be readily measured by the taphole yield factor. The taphole yield factor refers to the number of taps required to produce enough sap for one litre (one gallon) of standard density syrup. Standard density maple syrup has a sugar content of 66.0° Brix.

The number of tapholes required to produce a litre (gallon) of maple syrup varies from a high of around 2.2 (10) in low yielding sugar bushes to a low of about 0.7 (3) in very high yielding sugar bushes.

The taphole yield factor is a majo factor influencing the profitability o a maple syrup operation. Therefore, at the end of each maple syrup season, producers should compute the taphole yield factor for their sugar bushes. It is done by dividing the number of tapholes by the number of litres (gallons) of maple syrup produced that season.

Sugar Bush Productivity

Productivity Class	Taphole Yield Factor No. of Taps Required to Produce Enough Sap for 1 litre (gallon) of Maple Syrup
Excellent	Less than 0.7 (3)
Good	0.7 – 0.9 (3 – 4)
Average	1.1 – 1.3 (5 – 6)
Poor	More than 1.3 (6)

Wise management of the sugar bush will enable producers to lower the taphole yield factor which will increase production and returns in a maple syrup enterprise. High yielding sugar maple trees can be developed by the application of sound sugar bush management practices.

Most maple producers are aware that some sugar maple trees produce sweeter sap and larger volumes of sap than others. Considerable research has been carried out over the years in an attempt to identify the reasons for this variability. Vigorous, fast growing trees, with deep wide crowns are the best sap producers. Genetic and environmental factors play an important role in determining the variability of sap volume and sweetness among trees.

Judicious thinning, careful selection of crop trees, provision for regeneration and wise application of forest protection procedures will all serve to sustain, enhance and improve a sugar bush for the production of maple products.

The development of high sustained yield sugar bushes for sap production may be considered the main objective in this publication. There are numerous sugar bush management techniques and measures involved in doing this. These methods are discussed in detail in the following chapters.

Pioneer Maple Production and Management

Maple syrup time at Andrew Richards' sugar camp in 1900 - Dundas County.

To the pioneer farmer the forest was an enemy. The clearing of it involved long hours of toil and hardship. But the forests were also very important to him. Normally a woodlot of 4 to 10 hectares (10 to 25 acres) was left uncleared on each 40 hectare (100 acre) lot. Often it was decided to leave this woodlot at the back of the farm or on lands too stoney or steep for cultivation.

In southern Ontario wood was the main source of fuel for heating and cooking. Since sugar maple and beech made the best fuelwood, the pioneers reserved sugar maple-beech forests for fuelwood sources wherever possible. These sugar maple-beech forests often contained other species such as white pine, hemlock, white ash, white oak, red oak and basswood which were useful to the settler for construction materials or fuelwood. Furthermore in the spring of the year, the sugar maple provided settlers with a very valuable liquid from which the pioneers produced a much needed and highly prized food product – "maple sugar". Maple sugar was a staple food during the days of early settlement since coarse grained sugar was expensive and not readily available in rural Ontario at that time.

As settlement of the rural areas progressed, maple production in Ontario increased. During the pioneer period comparatively little syrup was made, most of it being boiled down to sugar.

Production of maple sugar reached a high of 3,168,000 kilograms (6,970,605 pounds) in 1861. This was about one-half of the 6,136,000 kilograms (13,500,000 pounds) produced in Canada that year. By 1871 production in Ontario had fallen to 2,840,000 kilograms (6,247,442 pounds) of maple sugar. A further decrease in production was reported in 1882 when 2,306,000 kilograms (5,073,610 pounds) of maple sugar were produced on Ontario's farms. This decline in production was due to the clearing of sugar bushes for farmland and to increased availability of cheaper cane sugar.

The early settlers tapped trees with an axe, auger or gouge. They soon learned that tapping with an axe caused considerable damage to the tree so this practice was quickly abandoned. Wooden spouts or spigots were used to convey the sap to wooden troughs or buckets. Wooden tubs or puncheons and wooden gathering pails were used to collect the sap. The first runs of sap made the best sugar while the last runs, when

The multiple kettle system of boiling.
Photo by: Public Archives of Canada.

the sap acquired a buddy flavour, were made into maple vinegar.

An iron or copper kettle was used to boil the sap. A multiple kettle system using three or four kettles was common practice. The boiling sap was transferred from one kettle to the next so that finished syrup or sugar would only be made in the last kettle. The first improvement on the old kettle was the sheet iron pan usually referred to as the flat pan. About 1880 the flue type evaporator was invented. With some modification, it remains today the best evaporator for producing high quality maple products.

Following the invention of the flue type evaporator a significant change in production and marketing occurred in Ontario's maple industry. An increasing amount of maple syrup was produced and retailed by farmers while much less sugar was made. In spite of its seemingly low price of $0.22 to $0.27 per litre ($1.00 to $1.25 per gallon) maple syrup was considered a luxury product.

The continual decline in maple production which had begun in the 1860's, ended around 1900 and production of maple products began to increase again due to the demand for maple syrup.

Management of the sugar bush was not important in pioneer days, since most farmers produced only enough sugar for their own use. Maximizing sugar production from a bush was not considered, since investment in equipment was minimal. Most of the equipment used was made from wood which was usually obtained on the farm.

The gradual removal of other tree species for construction material and fuelwood, benefited the growth of the remaining sugar maples. The prolific seeding nature of sugar maple often enabled it to quickly fill the openings with regeneration.

The removal of old growth maple and beech provided excellent fuelwood and long hours of sawing and splitting. Wood splitting and bucking "bees" were commonly held to speed up this laborious task.

The sugar bush was an integral part of early agriculture for many pioneer farmers. It often provided its owner with a sense of security, pride and value not commonly experienced in today's lifestyles.

(Top) Thinning in the sugar bush with a crosscut saw.
Photo by: The Late R. R. Sallows, Goderich, Ontario.

(Above) Gathering sap in 1897 at the Drummond sugar bush near Spencerville in Grenville County. George and Marilynne Drummond are fifth generation owners of this sugar bush which is Ontario's oldest continuous maple syrup operation, having been tapped every year since 1802.

Thinning the Young Sugar Bush In Preparation For Tapping

Selecting Crop Trees

In southern Ontario there are a great number of young upland hardwood woodlots containing an abundance of sugar maple. Many of these woodlots were established following the extensive clear-cutting of hardwood forests for fuelwood, sawlogs or pulpwood. They are usually referred to as second growth stands. Many others became established in abandoned agricultural fields.

These young stands are often vastly overstocked. There are too many stems growing on each hectare (acre). In stands ranging in age from 25 to 50 years, much can be done to develop crop trees for maple syrup production in the years to come. These trees usually range from 8 to 20 centimetres (3 to 8 inches) in diameter (outside bark at 1.4 metres ($4^1/_2$ feet) above the ground) depending on the density of the stand, productivity of the site and age of the trees. Young woodlots in this diameter range are called polewood stands.

Due to the abundance of sunlight in clearcut woodlots and in abandoned fields, many species less tolerant than maple may also become established. For example: basswood, *Tilia americana* L.; white elm, *Ulmus americana* L.; hickory, *Carya* species and oak, *Quercus* species are often found growing among the sugar maples.

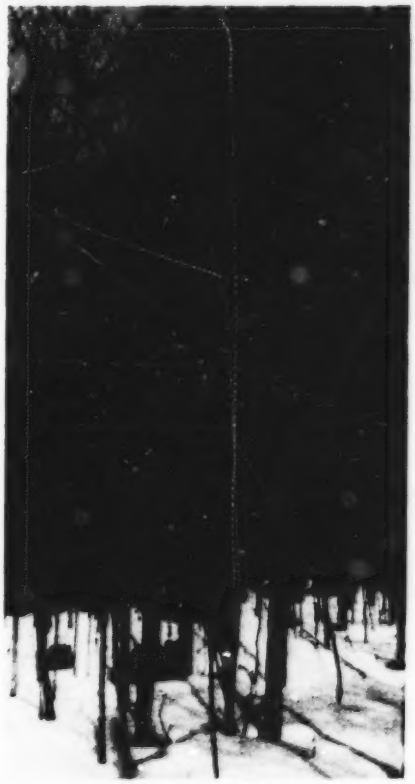
During the first 10 to 15 years of development in hardwood stands growth is rapid and as many as 25,000 – 50,000 stems per hectare (10,000 – 20,000 stems per acre) may be found.

Ideally, the thinning of the growing stock in the woodlot would commence at this time when the trees are 3 to 5 metres (10 to 15 feet) tall and about 2.5 to 5.0 centimetres (1 to 2 inches) in diameter. Selection and release of crop trees at this age encourages development of short boles and broad, deep crowns on the selected trees.

However most woodlot owners prefer to begin thinning when the young stands are about 25 to 30 years of age. Depending on the quality of the site, the average diameter at this time would be around 8 to 13 centimetres (3 to 5 inches). By this time, crown dominance is well expressed among the trees so that potential crop trees will be easier to

These maple trees are too crowded to develop deep, wide crowns. Crop tree selection and thinning should be carried out.

Author inspects sugar maple crop trees that have been released by thinning.



Removal of old growth beech and sugar maple trees about 15 years ago has released this excellent young stand of sugar maple. Crop trees should now be selected and a thinning carried out.

Young sugar maples in this sugar bush have been released from competition by the removal of other species. Note the well-developed fast-growing crowns on them.

Small openings made in the main canopy of the stand will enable the crop trees around the perimeter to broaden and deepen their crowns.

When thinning, double trees like this pair should be reduced to a single stem. Here the smallest and less vigorous stem on the left should be cut.

This young maple bush originated from a heavy fuelwood cut about 25 years ago. The remaining defective maples should be removed when the first thinning is carried out.

select, and sprout regrowth of cut stems will not offer crown competition. Approximately 250 crop trees per hectare (100 crop trees per acre) should be selected and marked with a tree marking paint.

Where possible, select crop trees at a spacing of 6 to 8 metres (20 to 25 feet) apart and release their crowns. Some reserve trees may be left between the crop trees if they are not competing with them for crown space.

Guidelines to follow When Selecting Crop Trees

1. Sugar maple should be selected over red and silver maple.
2. The tree should be dominant or co-dominant in the stand. These are normally the larger trees which have grown more rapidly than other trees of the same age.
3. Crop trees should have branchy vigorous crowns with short, clear boles preferably no longer than 7.3 metres (24 feet).
4. Crop trees should have trunks free of major defects such as sugar maple borer damage, large cankers, rot or acute forking.
5. Normally, sugar maple trees established from seed should be selected over trees growing from stumps.
6. Test the sap for sweetness. Choose healthy trees having the sweetest sap for crop trees. Since the sugar content may vary considerably during the day, make tests in groups over a period no longer than two hours. A sap refractometer should be used to test the sweetness. To obtain a drop of sap from the tree for testing, use a sharp awl to make a hole through the bark, then tap a hypodermic needle into the hole. Use a 13 gauge needle with a 2.5 cm (1 inch) stem. Wash the needle each time it is used. Hypodermic needles are available at drug stores.

Objective of Thinning

The objective of thinning is to remove trees adjacent to the selected crop trees to provide more growing space for them. In dense young stands, individual tree growth is slow. Thinning permits room for expansion and development of the crowns of crop trees and reduces the competition for moisture and nutrients in the soil. The result is that the growth rate of the crop tree is in-

creased. For example, crop trees, which may be growing 2.5 centimetres (1 inch) in diameter every eight to twelve years before release, may grow as much as 2.5 centimètres (1 inch) in diameter in three to five years following release.

Rapid growth will continue until the stand becomes closed again and further thinning is required. Dense young sugar bushes at the time of the first thinning will usually contain over 4900 stems per hectare (2,000 stems per acre). They should be reduced to approximately 250 stems per hectare (100 stems per acre) by the time the average diameter reaches 25 centimetres (10 inches) and the woodlot is ready to tap. At least 200 crop trees per hectare (80 crop trees per acre) should remain at this time plus a few reserve trees.

The interval between thinnings will depend on the size of the openings and the rate of growth of the crop trees. Large openings should not be made when thinning small trees because of the danger of sunscald or wind damage to exposed trees. Openings 1.8 – 3.0 metres (6 – 10 feet) in diameter are large enough. The interval between thinnings carried out in this manner would be from five to 10 years. Thinning should not be carried out within 15 metres (50 feet) of the edge of the woodlot since the trees here form an effective windbreak.

In the initial thinnings some of the small trees will not be large enough for sawlogs or pulpwood.

Some of this wood may be utilized as firewood for evaporating. In recent years good markets for fuelwood have developed for home heating, and this smaller material is often sold for that purpose.

Benefits of Thinning

Thinning the young sugar bush is an investment in the future which offers the following advantages.

1. Vigorous sugar maple crop trees will develop large, wide, deep crowns and will produce sweet sap.
2. Since the crop trees are the trees with the sweetest sap, production of maple syrup at the time of tapping will be maximized.
3. Crop trees in the thinned woodlot will reach tappable size several years before trees in a similar, unthinned woodlot.

The non-sap producing species and defective maples have been removed from this sugar bush. The owner inspects the crop trees which will now reach tapping size much sooner.

4. The non-sap producing species, e.g., elm, ash, basswood, etc., will be removed and the site will be fully utilized by sugar maple.
5. Multiple stems are reduced.
6. Density of trees is controlled.
7. The most seriously damaged and defective maples are removed.

Thinning the young sugar bush is an investment in the future which offers many advantages. Note the contrast between the thinned area of the woodlot in the foreground and unthinned section in the background.

Thinning the Tapped Sugar Bush to Increase Sap Production

Many sugar bushes are remnants of the old hardwood forests which have been reserved for maple syrup production because of the dominance of maples in them. Sporadic cutting throughout these stands over the years has supplied fuelwood and sawlogs for the owners. This type of cutting has produced uneven aged woodlots.

The management of a sugar bush involves a continuous programme of thinning in order to obtain high yields of sweet sap which will maximize returns from the maple syrup operation. Therefore, the problem which faces most sugar bush owners today is one of improving the species content, vigour and quality of their woodlot by selective cutting.

The selection system of woodlot management is the ideal system of management for sugar bush owners wishing to obtain high, sustained yields of sweet sap.

Improvement Cutting

The present and future harvesting necessary in most sugar bushes is referred to as improvement cutting.

One objective of an improvement cut is to develop the best growing conditions possible for the selected crop trees so that a high, sustained yield of sweet sap may be obtained, thus maximizing syrup production. To do this, certain trees are removed and others are favoured and left in every woodlot.

When improvement cuts are carried out, particular care must be taken to prevent damage to remaining trees. In cases where the owner is not able to carry out the cutting and extraction, be sure to sell to a reputable individual or firm that has experience in thinning sugar bushes. Always have your family lawyer draft a legal contract for the sale of standing timber.

Crop Tree Selection

Before removal commences, crop trees should be selected and marked with a tree marking paint.

Crop trees are maple trees that are currently good sap producers, or that show prospects of becoming good producers.

It is recommended that the owner obtain the assistance of a local forester in assessing the crop tree situation.

A sugar bush should not be thinned by attempting to remove all defective and non-sap producing trees at one time since in some stands, few trees would be left and wind-throw and breakage could destroy many more. Instead, a sugar bush should be thinned by selecting crop trees and over the years cutting the trees around them to provide increased growing space.

The number of crop trees per hectare (acre) depends on the average diameter of the trees in the stand. Fewer crop trees per hectare (acre) are required as the average diameter of the trees increases. (See Appendix A). This is due to the fact that the number of tapholes per tree increases as tree diameter increases.

A well managed sugar bush should contain from 175 to 225 tapholes per hectare (70 to 90 tapholes per acre) which are capable of producing 168 to 280 litres (15 to 25 gallons) of maple syrup per season.

Crowded sugar maple trees develop long boles and narrow shallow crowns which are not ideal for maple sap production.

(Below) Dense old growth maple bushes may have over 370 taps per hectare (150 taps per acre). However, they contain very few young maples to replace older trees when they die.

An ideal sugar maple tree for sap production. To produce large sustained yields of sweet sap the development of wide, deep crowns is essential.

Crown Release

When thinning is carried out in a sugar bush to favour the crop trees, the crowns of the favoured trees are released from the competition of neighbouring trees. This is commonly referred to as crown release.

The size of the opening will depend on the crown spread of the tree or trees removed. Large openings over 4.6 metres (15 feet) in diameter are not necessary unless regeneration is the objective. The growth of healthy maple crop trees will normally increase the year following thinning. The crowns will soon fill in small openings and at that time further thinning may be necessary.

Crown release of the selected crop trees is important since increased growing space, sunlight, moisture and nutrients are provided for the rapid development of deep broad crowns.

Over-mature and mature trees do not respond to crown release. Depending on the condition, age, and vigour of these trees, sudden exposure by thinning may cause dieback in them.

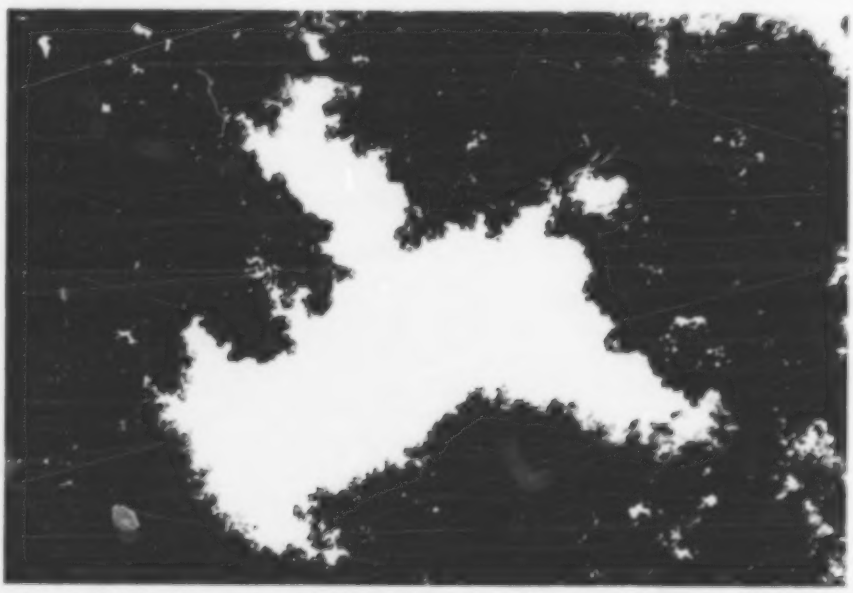
Regeneration

Adequate sugar maple regeneration is an important management objective. Improvement cuts involving the removal of old growth maple trees or groups of other species from a stand will make openings large enough to provide sufficient space and direct sunlight for maple regeneration.

Sugar maple regenerates from seed and freshly cut stumps. Good seed crops occur every four years. Regeneration from stumps is referred to as stump sprouts or stump coppice.

Although sugar maple is tolerant to shade, some direct sunlight is necessary for good growth of the seedings. Sugar bushes averaging from 175 to 225 tapholes per hectare (70 to 90 tapholes per acre) should provide adequate space for regeneration. Sugar bushes with more than 225 tapholes per hectare (90 tapholes per acre) do not make adequate provision for regeneration.

By providing for regeneration, sugar bush owners are ensuring that younger trees will be present in the stand to replace old growth and defective trees when they are harvested.



(Upper Left) Undergrowth of young sugar maple seedlings in a productive sugar bush. Since they are tolerant to shade, many of them will survive for several years but their growth will be very slow. When released they will respond immediately to the sunlight by increasing their rate of growth.

(Upper Right) Sufficient sunlight reached the forest floor to permit establishment of this dense understory of sugar maple saplings.

(Above) Removal of an old growth maple provided this large opening in the main canopy of the stand.

Trees to Remove in Improvement Cuts

As a general guide the following trees should be removed from the sugar bush in improvement cuts, particularly when they are competing with selected maple crop trees.

1. **Overmature Trees**

These larger and older trees are less vigorous and should be removed to allow greater light, soil moisture and nutrients for adjacent maple crop trees and to provide openings in the stand for the establishment of regeneration. Overmature trees often have dead branches in their crowns, and heart rot in their trunks. They are not good sap producers.

2. **Diseased and Defective Trees**

Diseased and defective trees should be removed to allow more growing space for adjacent healthy maple crop trees. Examples of trees that should be removed are:

(a) Trees struck and damaged by lightning.
(b) Trees with dying crowns

(Maple decline).

(c) Trees with fungus conks on their boles. Fungus conks are indications of advanced heart rot within the bole of the tree. Heart rot fungi usually enter the tree through tapholes, wounds or dead branch stubs.

(d) Trees infected by large nectria and eutypella cankers. These cankers are perennial. They often develop in wounds made during felling and skidding operations or during sap collection.

(e) Trees damaged by the sugar maple borer that have become seriously infected with rot or canker.

3. **Low Producers**

Trees producing sap with a sugar content less than 1° Brix.

4. **Trees of Other Species**

Many other species of trees may be found in the sugar bush. In an operation using plastic tubing, costs increase when lines have to pass other species. Coniferous trees such as hemlock, *Tsuga canadensis* (L.) Carr; white spruce *Picea glauca* (Moench) Voss; white cedar, *Thuja occidentalis* L. and white pine, *Pinus strobus* L. will shade the tubing and tapholes delaying the thawing of ice. If the objective is to maximize sap production, the non-sap producing species of trees should be gradually removed so that all the growing space is available for sugar maple crop trees.

Trees to Leave

(1) *Trees which are presently good producers*
This means trees producing sap with high sugar content combined with high volume production.

(2) *Young vigorously growing maple trees*
Young vigorous maple trees should be selected as crop trees since they are usually good potential sap producers. Test their sap for sweetness. Choose those with the sweetest sap.

(3) *Healthy trees with large crowns*
Trees with deep, broad crowns are usually the best producers, but there are exceptions.

(4) *Edge Trees*
Heavy thinning should not be carried out on the borders of the bush since these trees form

Removal of an Ironwood understory in this woodlot was the first step in providing suitable conditions for the establishment of sugar maple regeneration.

Defect-free sugar maple trees have been left as crop trees in this thinned sugar bush.

Maple trees with broken tops like this one do not make good sap producers. They should be removed in an improvement cut.

This rotting beech tree should be removed in an improvement cut.

a dense windbreak which conserves soil moisture in the bush by reducing drying winds.

Care and Good Judgement are Essential When Thinning

Care and good judgement are essential when thinning in productive sugar bushes. Many sugar bushes have not been thinned regularly and their development has not produced ideal trees for maple syrup production. In unthinned stands, trees develop with long boles and narrow, shallow crowns. These stands are too dense to provide for vigorous growth and deep wide crown development which produces desirable trees for maple syrup production.

Furthermore while thinning is beneficial and necessary, the timing or scheduling of thinning operations is equally important.

Sugar maple trees on good sites grow to a maximum height of 24 to 27 metres (80 to 90 feet). Once a tree reaches this height, release will not benefit the tree by enabling it to develop a deeper crown. Therefore, in order to obtain maximum benefits from thinning, trees must be released before they reach their maximum height. The longer thinning is delayed in a stand, the less chance there is for developing deep, wide crowns in the existing overstory.

There are many variables to assess in thinning the operational sugar bush. Tree condition, height, age, stand density, site and stress factors are important factors that must be considered in managing the sugar bush. The taphole yield factor must also be considered and the opportunity to improve it carefully appraised. Thinning to maintain or produce good tree vigour is a major factor in improving taphole yield.

Special Management Consideration For Old Growth Or Severely Stressed Sugar Bushes

In old growth, unthinned sugar bushes and/or woodlots where factors combine to produce a high degree of stress in the trees, heavy thinnings should not be carried out unless the owner's objective is to open up the stand to provide growing space for regeneration. Vigorous healthy maple trees normally respond to release from thinning by increasing their rate of growth and expanding their crowns to fill in the openings. However, old growth, overmature trees and trees which are severely stressed do not react in this manner. They do not respond positively to the release at all and the increased exposure may result in the onset of maple decline in the remaining trees exposed by the thinning.

In situations like this where the maple producer wishes to continue tapping the stand without losing a large number of taps, only light thinning to remove dying trees is recommended for the immediate future. Since old growth, or otherwise severely stressed situations normally occur in only portions of woodlots, thinning restrictions would apply only to those affected portions.

To help accurately assess the situation it is important that maple producers consult with a forester before commencing thinning.

Thinning Old Growth Maple to Provide For Regeneration

A sugar bush management program to suit the short term needs of the maple syrup producer is feasible in all maple woodlots except old growth even-aged or severely stressed sugar maple stands. It is very difficult to recommend improvement cutting and crop tree selection where these conditions are present since many trees will have to be removed to encourage regeneration which, of course, will not reach tappable size for many years.

The removal of many trees would cause a drastic reduction in the number of taps available and make the maple syrup operation unprofitable unless the owner rents taps from neighbouring sugar bush owners.

While the short term needs of the producer are difficult to meet by thinning old growth sugar bushes, the long term requirements may be satisfied by removing old growth trees in groups making clearings up to 0.4 hectare (1 acre) in size. These clearings are large enough to provide good conditions for establishment of natural regeneration of sugar maple. Depending on the size of the woodlot the old growth stand should be removed after three or four harvests have been made. The harvests should take place every eight to ten years. Following the gradual and complete removal of the old growth trees, the woodlot will be uneven-aged. Management practices as recommended for thinning the young sugar bush should be applied then in developing the new stand for tapping.

It has been demonstrated that the application of commercial fertilizer in a sugar bush will increase sap production. An experiment carried out by the Ministry of Natural Resources indicated that an application of 280 kilograms (250 pounds) of ammonium nitrate per hectare (acre) per year for four years provided a significant increase in sap production. Further experimentation is necessary in order to obtain cost-benefit information regarding its use.

Tree Marking In the Sugar Bush

Management of the sugar bush for sap production requires that trees be marked for future identification purposes. The best method is to use a specially prepared, tree-marking paint which is long-lasting and shows up clearly on the trunks.

Tree-marking paint is available in 454 gram (16 ounce) aerosol cans and by the litre or 4 litre containers. It is also supplied in tubes for numbering the trunks of trees.

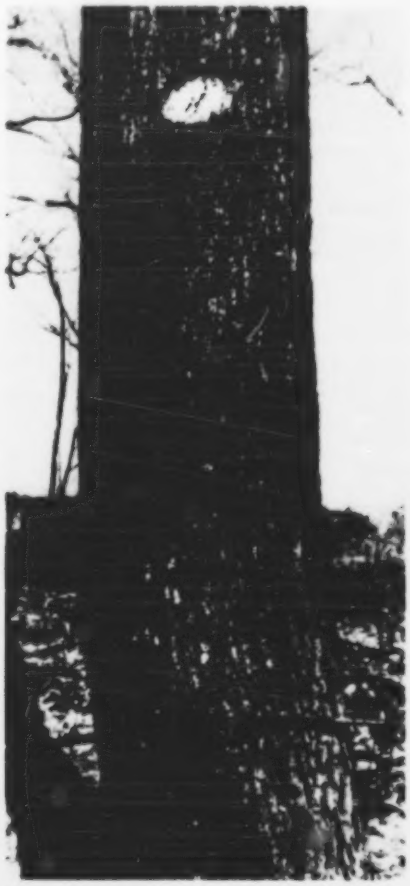
A 454 gram (16 ounce) aerosol container should spot-spray 200 to 300 times depending on the size of the spots. While the cost of the paint is slightly higher when purchased this way, the over-all cost of paint would not be excessive for small marking jobs. When using aerosol cans, trees should be marked when the temperature is above freezing. Tree-marking paint will remain visible up to ten years after the application.

The 140 gram (5 ounce) tube markers are also suitable for use in tree marking, particularly when numbering or lettering. They work best when the temperature is well above freezing. By making a generous application of paint and using approximately 5 cm (2 inch) numbers, one tube should number up to 100 trees. The numbers should remain visible for ten to fifteen years.

The colours recommended in the following guidelines are suggestions only. Care must be taken when choosing colours in order to avoid future confusion of the markings. Do not waste paint by making oversize markings on trees.

(Top) To facilitate setting up plastic tubing gathering systems the trees may be numbered individually.

(Above) Arrows indicate the direction of the lines for future reference when setting up tubing systems. Using only one hook on the arrows saves paint.



The white spot of paint indicates that this is a one tap tree.

Guidelines for Using Tree Marking Paint in the Sugar Bush

1. **Tree Marking for Thinning**

It is customary to mark trees for removal with a spot of yellow paint applied to the trunk 1.4 metres ($4^1/_2$ feet) above the ground. Trees should be marked on the same side so that the spots will all show from the same direction.

If the trees are to be removed by a commercial operator, two spots should be applied, one at 1.4 metres ($4^1/_2$ feet) above the ground, and one just below stump height. The spot on the stump enables the woodlot owner to maintain a check on the thinning operation, making sure that only marked trees are removed.

2. **Boundaries**

When thinning operations are carried out, it is essential to know the boundaries of the woodlot. If the boundaries are not distinct, they should be marked, using red tree-marking paint.

3. **Crop Tree Marking in Young Woodlots**

In young, crowded, polewood stands not yet large enough to tap, mark good quality, potential sugar maple trees as crop trees. Crop trees should be released from the competition of surrounding trees so they may develop broader and deeper crowns. This will increase their vigour and rate of growth thus permitting tapping at an earlier age. Blue paint should be used to mark young crop trees for future reference.

4. **Tree Marking to Indicate the Number of Taps**

In tappable stands the crop trees that are large enough to tap should be measured. The number of taps should be indicated by spraying white paint spots on the tree trunk about 1.4 metres ($4^1/_2$ feet) above the ground. A tube marker could also be used to indicate the number of taps simply by noting the recommended number of taps on the trunk of each tree. Remeasurement of the trees would be necessary about every 5-10 years. Hence the young potential crop trees in a stand are indicated by a spot of blue paint while the producing crop trees are marked by indicating the number of taps per tree with white paint spots.

5. **Painting for Tubing Layouts**

Tree-marking paint is also useful in marking tubing layouts for future reference. Starting at the main line, arrows are painted on the trees to denote the direction of the lateral line layouts. Lateral lines may be colour-coded, and the arrows should be the same colour.

Tapping to Obtain Maximum Sap Production

Minimum size of tree recommended for tapping is 25 cm (10") in diameter measured outside bark at breast height, 1.4 metres ($4^1/_2$ feet) above the ground.

When to Tap

With suitable weather conditions maple sap will flow anytime after the trees have lost their leaves in the fall until late spring when the trees begin to leaf out.

Sap flows on warm days which follow frosty nights. Good flows occur when the daytime temperature rises to about 7.2° Celsius (45° Fahrenheit) following a frost the night before.

Tapping should be carried out early enough in the spring to ensure that the first good runs of sap are obtained.

If paraformaldehyde pellets are used the danger of tapping too early is removed. In southern Ontario good runs of sap may commence anytime after the first of March. On the average, however, good runs usually commence about the second or third week of March, and continue sporadically for a period of four to six weeks. Experiments have shown that slower taphole closure takes place when tapholes are drilled in frozen trees. Ideally tapholes should be drilled when the temperature is above −3.8° Celsius (25° F).

Size of the Tree

The trees selected for tapping should have a diameter of at least 25 cm (10 inches), measured outside the bark 1.4 metres ($4^1/_2$ feet) above the ground. It is considered harmful to tap trees under 25 cm (10 inches). Sap production is low from small trees.

Tapholes per Tree

The number of tapholes depends on the diameter of the tree. The general rule is as follows:

Diameter of Tree Measured Outside Bark 1.4 Metres ($4^1/_2$ Feet) Above the Ground	Number of Tapholes Per Tree
Less than 25 cm (10")	0
25 – 36 cm (10" – 14")	1
37 – 48 cm (15" – 19")	2
49 – 61 cm (20" – 24")	3
62 cm and larger (25")	4

Each tree should be measured before tapping and a paint mark placed on the tree to indicate the number of tapholes for reference in future years.

Producers with slow growing trees or old growth sugar bushes may wish to tap more conservatively than indicated by the above rule. Poor tree vigour or slow growth can readily be assessed by checking taphole closure. Tapholes in vigorous fast growing trees will heal over in 2 or 3 years. If fewer taps are set out, then it follows that sap production will be lowered.

To undertap trees lowers the potential volume of sap that may be produced in a sugar bush. To overtap trees will result in excessive staining in the sapwood. To increase sap volume it is better to use a tubing and vacuum system of collecting rather than resort to over-tapping.

Tapholes per Hectare (Acre)

The number of tapholes per hectare (acre) depends on the diameter of the trees and the species composition of the bush. A well managed sugar bush contains from 175 – 225 (70 – 90) tapholes per hectare (acre). Over a period of time, by carrying out proper thinning, the number of tapholes in many woodlots could be increased.

Old growth sugar bushes have been known to contain over 370 taps per hectare (150 taps per acre), but these woodlots do not contain sufficient young growing stock to replace the old growth trees.

Location of Tapholes

For maximum sap yield, the taphole must be located in white sapwood. Shortly after a taphole is bored in a maple tree, the wood in the vicinity of the taphole becomes discoloured. If tapholes are drilled the following year into the discoloured wood, sap yields will be much lower than normal. There is less chance of striking an old taphole, or stained wood if the new tapholes are located in a spiral pattern, 15 to 20 cm (6 to 8 inches) from the previous ones. Although the warm side is favoured by many producers, the total yield is essentially the same regardless of the

compass location of the taphole. The high speed of some mechanical tappers does not affect either sap volume production or sweetness of sap.

Diameter of the Taphole

A round taphole diameter of 7/16" is recommended. Smaller tapholes will yield significantly less sap while larger tapholes do not produce significant increases.

Larger tapholes cause unnecessary injury to the tree and take much longer to heal over. Also the chance of decay developing is increased. Care should be taken to drill round rather than oval tapholes. Keep taphole bits sharp.

Depth of Taphole

The yield of maple sap is related to the depth of the taphole. Maximum sap yield will normally be obtained if tapholes are drilled 7.6 cm (3 inches) into the white sapwood of the tree. This must be considered when tapping so that tapholes are drilled deep enough. Tapholes 7.6 cm (3 inches) deep will produce up to 25 percent more sap than tapholes only 5 cm (2 inches) deep. Tapping deeper than 7.6 (3 inches) is not recommended since no significant increase in sap yield will occur.

With some trees a taphole 7.6 cm (3 inches) deep may extend through the productive white sapwood into the "red" heartwood. Since heartwood or stained wood does not produce sap, drilling should stop when it is reached. Furthermore, tapholes should not be drilled into decayed wood. When vacuum is used, do not tap into a hollow tree trunk, as this would permit air to enter the tubing resulting in a loss of vacuum in the line beyond the taphole. Use high yield spiles that do not block off the outer sapwood since the sweetest sap flows here.

Height of Taphole Above Ground

The yield of sap does not vary significantly as you move up and down the bole of the tree. However, the yield of sap would be less if the tapping was carried out in the vicinity of the branches. Normally trees are tapped 0.9 to 1.2 metres (3 to 4 feet) above the ground. However, when tubing is used, trees may be tapped much higher to create a suitable slope in the tubing system.

Over-tapping results in excessive staining in the sapwood. This practice is discouraged.

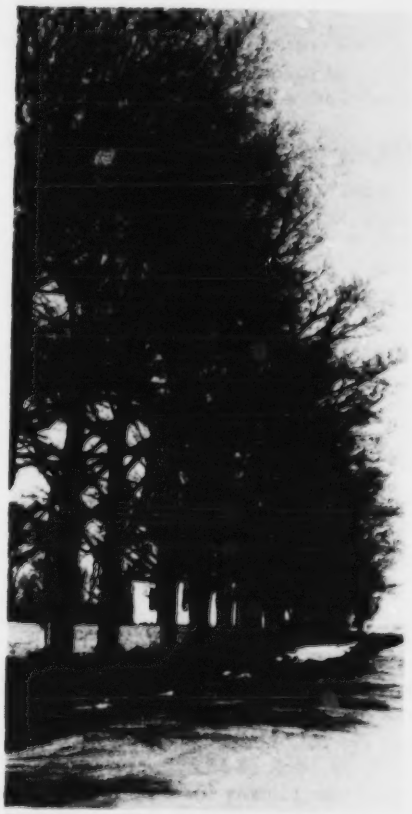
Power chainsaw with adapter for use in tapping.

Life of a Taphole

A taphole should be useable from the time it is bored until the syrup develops a buddy flavour. Tapholes often dry up three to four weeks after boring. This is commonly caused by growth of micro-organisms in the taphole.

About 1962 the paraformaldehyde pellet was introduced. One pellet is inserted into the taphole right after it is bored. The pellet will reduce the growth of micro-organisms in the taphole throughout the sap season. When paraformaldehyde pellets are used, the trees may be tapped before the sap season with the assurance that the first as well as the last run of sap will be obtained. The effects of paraformadehyde vary from nil to over a 50% increase in sap production. The results depend largely on the weather during the sap flow season.

Recent research has indicated that the use of paraformaldehyde pellets



Healthy roadside or open grown trees with deep crowns are often tapped since they produce sweet sap.

may harm the trees.

Statistical analysis has indicated in recent experiments that there was more decay associated with tapholes treated with paraformaldehyde pellets than untreated tapholes.

In deciding whether to use these pellets, sugar bush owners must weigh the possible long term damage to the tree against the benefits of greater sap yield at the time of tapping. To use these pellets is a management decision.

It has been demonstrated that paraformaldehyde pellets are unnecessary when vacuum is used on a closed tubing system.

Sweetness of Sap

The sugar content in the sap of sugar maple trees may range from less than 1° Brix to greater than 10° Brix. The sap produced by an average tree in a woodlot has a sugar content of 2° to 3° Brix. Roadside trees and other open grown maples with deep broad crowns usually produce sweeter sap. The owner should measure the sugar content of the sap of each tree using a sap hydrometer and thermometer or a sap refractometer.

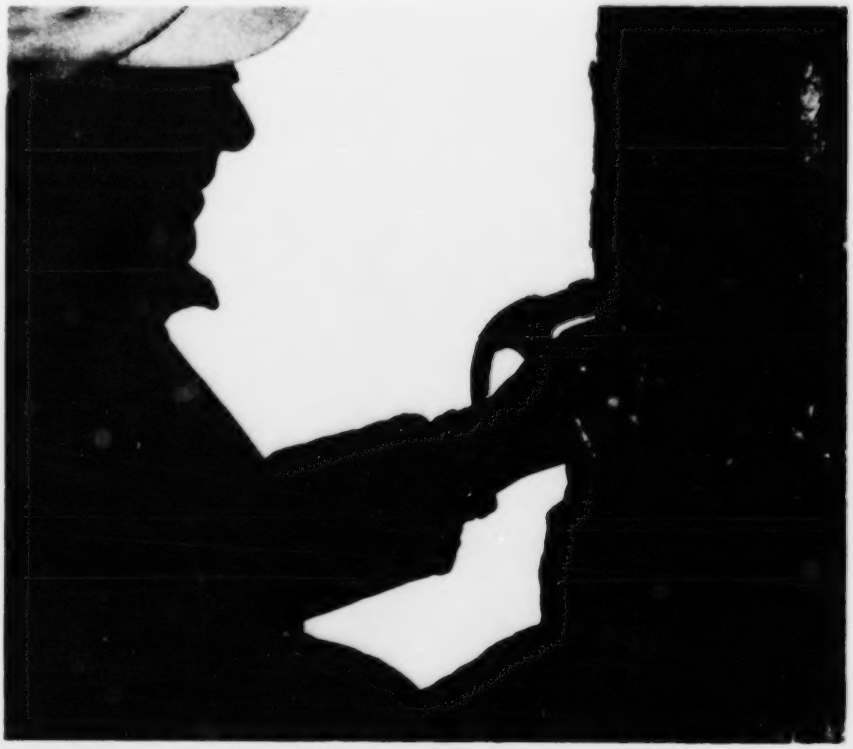
Trees producing sap with a density of 1° Brix or less should not be tapped. They should be harvested so more growing space is provided for good producers.

The yield of sap from a tree may vary from year to year. Trees that produce sap with a high sugar content and trees that produce sap with a low sugar content, maintain their relative positions from year to year. Therefore, it is unnecessary to determine the sugar content of the sap every year.

Use of Vacuum Pumps

Many sugar bush operators are using plastic tubing and vacuum pumps to move sap from the trees to holding tanks. Taphole yields using vacuum pumps on unvented or closed tubing systems have produced as much as threefold increases in sap production over similar vented gravity tubing or bucket systems.

Many producers have expressed concern that large increases in sap production may be detrimental to the health and vigour of the tree. There is at present, no indication that this is correct.



Drive spiles in snugly. Do not drive them too hard as the bark may split causing them to leak.

When plastic tubing is used, the tapping height may vary considerably to obtain a desirable slope in the system. Sap production does not vary significantly as the tapping height on the tree trunk is changed.

The application of vacuum to the unvented or closed tubing system will often increase sap production. The largest increases occur in years when natural or gravity flow is poor due to unfavourable weather conditions.

The reasons for the increases in sap production are as follows:

1. There is no sap loss due to spillage or overflowing buckets.
2. There is no sap loss due to obstructions in the tubing such as ice or air locks which would cause vents to run over.
3. Since vacuum removes most of the sap from the tubing at the end of the day, there is a reduction of sap loss by preventing re-absorption into the tree at night.
4. Large increases in sap yield are obtained with vacuum when natural flow is slow. This means that on days when weather conditions are marginal for natural or gravity flow, significant volumes of sap can be obtained using a vacuum system.

Vacuum systems can be of great value during poor sap seasons. Maple producers are aware that there is often considerable variation from year to year in sap production. This variation is caused mainly by weather conditions during the sap season. The use of vacuum helps to reduce this large difference in annual production.

Metal covers are used with buckets to help keep out snow, rain, bits of bark, etc.

Protecting the Sugar Bush

Protection of the maple trees in a sugar bush is an important aspect of management. Knowledge of the enemies of the woodlot and periodic inspections can result in locating problems before damage becomes serious.

Grazing

The sugar bush must be protected from grazing by livestock. Light grazing by a few animals for a month would not produce the same damage as long term grazing by several animals. Interruptions in grazing for a few years will also vary the damage caused by livestock.

The foliage of sugar maple is particularly palatable to livestock. Sugar maple regeneration is therefore quickly destroyed by grazing animals. The foliage of several undesirable trees and shrubs such as ironwood, *Ostrya virginiana* (Mill.) K. Koch; blue beech, *Carpinus caroliniana* Walt.; hawthorn, *Crataegus* species and prickly ash, *Xanthoxylum americanum* Miller are not browsed even during periods of heavy grazing. Grazing therefore encourages the growth of these undesirable species, leaving them to fill the openings which should be occupied by sugar maple.

(Top) Intensively grazed sugar bush as evidenced by the distinct browse line.

(Above) Intensive long term grazing by livestock has destroyed the delicate leaf litter and humus layers exposing the mineral soil.

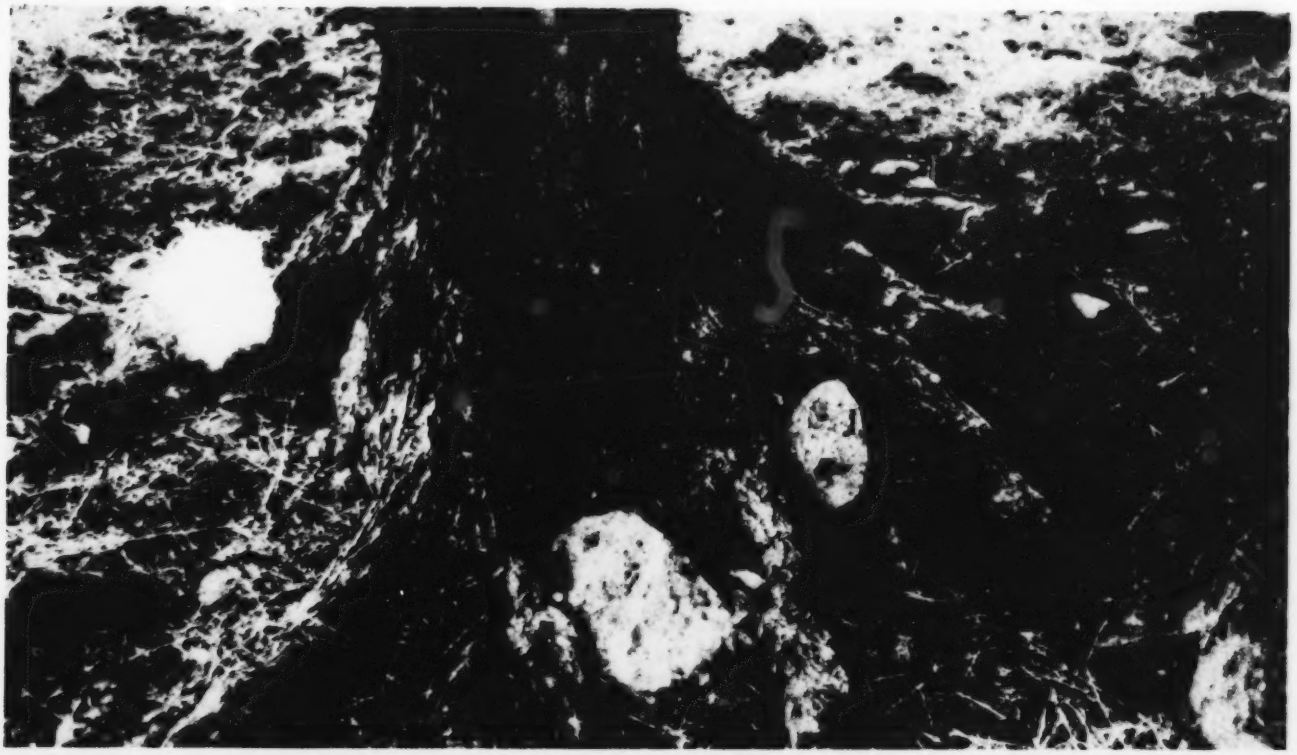
Light Grazing

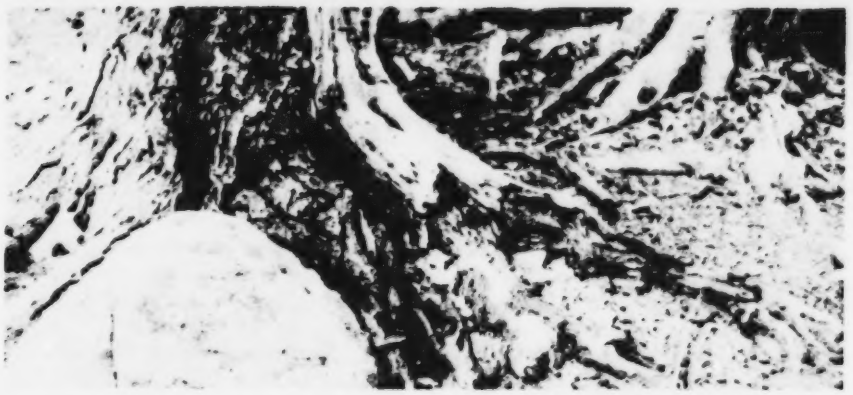
The effects of light grazing on a sugar bush can be detrimental. Livestock quickly browse on the tops of sugar maple seedlings, deforming and sometimes killing them. Wandering livestock compact the soil, and reduce its water-holding capabilities. Although not readily visible, tree vigour and growth decline even with light grazing. Besides being harmful to the trees, light grazing is not recommended since the forage value in a woodlot is relatively low, compared to that of a managed pasture. Furthermore the bush may contain many plants and shrubs poisonous to livestock such as black cherry, *Prunus serontina* Ehrh L.; choke cherry, *Prunus virginiana* L.; pin cherry, *Prunus pensylvanica* L.; bracken fern, *Pteridium aquilinum* L.; white snakeroot, *Eupatorium rugosum* Houtt.; St. John's-Wort, *Hypericum perforatum* L.; Dutchman's breeches, *Dicentra cucullaria* (L.) Bernh. and some night-shades, *Solanum* species. Certain plants and shrubs found within or at the edge of a sugar bush will cause a decrease in milk production when cows feed on them.

Long Term Intensive Grazing

The results of long term intensive grazing are very detrimental to the woodlot. The damage caused by intensive grazing is variable. This variability depends on a number of factors such as: topography, age of the trees, seed sources in the vicinity and soil type. The following conditions may arise as a result of intensive grazing:

1. The wandering of livestock destroys the loosely arranged leaf litter and humus thus exposing the bare mineral soil.
2. Mechanical damage to the roots occurs. Roots are then subject to infection by wood-rotting fungi.
3. Sugar maple regeneration will be browsed heavily and can be completely destroyed.
4. Long term grazing reduces the stand density since many trees are killed. Eventually with the added sunlight falling on the forest floor, grass will invade the area.
5. Depending on the seed source available in the vicinity, undesirable species such as ironwood, hawthorn, prickly ash, etc. may invade the sugar bush and restrict any future maple regeneration until this canopy is removed. The heavy shade produced by these species will not permit the establishment of maple regeneration.
6. Extended grazing causes a substantial increase in the occurrence of butt rot in the sugar bush. The high incidence of butt rot reduces tree vigour and lowers sap production from those trees still living. Dead branches in the tree tops will also appear.
7. Compaction of the soil causes water to run over the land and induces erosion on steep slopes.





(Above) Excessive root exposure caused by intensive grazing.

Damage to roots caused by wandering livestock resulting in decay.

(Far Left) This intensively grazed woodlot has regenerated to ironwood. Livestock do not browse on ironwood. The first step in managing this woodlot would be to remove this ironwood understory.

(Left) Invasion of prickly ash in a grazed sugar bush.

8. Compacted soil, reduced availability of moisture and mechanical root damage will cause a considerable reduction in tree vigour and growth. Diameter growth is severely reduced so that tapholes will take several years to heal over.

9. Livestock will damage the bark on tree trunks by rubbing against them.

10. Trees will mature and die at an earlier age in a heavily grazed woodlot.

The Effect of Grazing on Maple Sap Production

Some syrup producers believe that grazing actually improves certain aspects of their maple business. Yields of sweet sap are sometimes experienced in grazed sugar bushes because of the large crowns which have developed. However, sap flow may be reduced in woodlots with no regeneration or undergrowth by cold north winds. It is better therefore to obtain large crowns on maple trees through a sensible program of thinning rather than by grazing.

Some producers feel that pasturing is a benefit since pastured woodlots often contain very few young trees and this makes it convenient for gathering sap or setting up plastic tubing. However, this is a problem solved, only to create another. Woodlots without young seedlings and saplings eventually become overmature. These trees die and no trees of tappable size are present to take their place. A producer finding himself in this situation would be forced to rent taps elsewhere in order to continue.

Decreased tree vigour, increased butt rot, dead tops and reduced water available to the root system from compaction by grazing all reduce sap production.

Road System

Roads play an essential role in a good sugar bush management program. While the first thinning is being carried out in a young sugar bush it is important to lay out and establish a road system. In older sugar bushes it may be necessary to expand and improve the existing road system.

A good road system should provide easy access to all parts of the bush. The length, width, spacing and direction of roads should be determined by the topography and the main purpose for which the roads will be used. A maintenance program is needed to keep roads in passable condition. Infrequently used roads which gradually grow in to young trees can be cleared by using a tractor-mounted rotary brush cutter provided the ground is not too stoney.

Occasionally road building in the sugar bush, especially when roads are gravelled causes alterations in the natural drainage of the soil. This may result in an increased summer water table in the soil which will reduce tree vigour and in extreme situations, result in the death of numerous maple trees on the site. (Maple Decline).

Deep rutting of the soil with tractors in the sugar bush should be avoided as it damages the tree roots.

A good road network in the sugar bush provides the following benefits:

1. Quick and easy access in the event of a ground fire.
2. Good access for gathering sap from buckets. This reduces the time and expense involved in gathering sap by hand.
3. Roads may be used by

(Top) Intensive grazing has completely destroyed the maple regeneration in this sugar bush. Following the complete exclusion of livestock a grassed over woodlot will often regenerate slowly to sugar maple.

(Above) Intensively grazed woodlot. All regeneration has been browsed and destroyed.

Severe hurricane damage in a productive sugar bush. Well rooted, sound sugar maples were toppled.

Trees containing extensive heart rot are particularly prone to breakage in high winds.

Trees with acute forking like this one are particularly susceptible to wind damage. Severely damaged trees should be removed.

snowmobiles when setting up plastic tubing.

4. Access for the extraction of timber and fuelwood harvested in improvement cuts. Damage caused by logging will be minimized.
5. Cost of wood extraction will be reduced.

Fire

Although fires are not common in hardwood woodlots, occasional ground fires may damage the bark around the base of trees thus permitting fungi and other organisms to enter and cause decay. Fire also destroys the surface litter and humus which are important for holding moisture in the soil. Removal of this material increases run-off and soil erosion, particularly on hillsides. The future crop of seedlings and saplings may also be destroyed.

Wind, Snow, And Ice

It is a good idea to protect the bush from wind by planting a windbreak on the windward side. A windbreak should consist of several rows of white cedar, white spruce or Norway spruce. (*Picea abies* (L) Karst.) (syn. *Picea excelsa Link*). By reducing the wind velocity, evaporation of the soil moisture will be reduced. Windthrow and breakage will be minimized. Winds of hurricane force sometimes cause considerable damage to large well developed sugar maples. The large heavy crowns which are essential for good yields of sweet sap are very prone to high wind damage. When high winds and hurricanes strike, damage in heavily pastured woodlots is particularly severe since heart and butt rot is higher than normal. Fortunately the occurrence of hurricanes in Ontario is low and heavy damage to sugar bushes is infrequent.

Heavy snow or ice may break branches in the crowns of maples. Silver and red maple are more susceptible to this damage than sugar maple. The possibility of damage is reduced if the trees are maintained in a vigorous, healthy condition. If the trees are tall and slender, careful consideration must be given when thinning the bush so that large openings are not made since this may result in windthrow and breakage from snow, ice and wind.

Sunscald

Sunscald is caused by an overheating or drying out of the bark in the summer or by alternate freezing and thawing in late winter or early spring. It results in open wounds or splits on the trunk of a tree.

Sunscald occurs on young trees with thin bark. Sugar maple is susceptible. It may occur on young sugar maples when heavy thinning takes place suddenly exposing the tree trunks to direct sunlight.

Sunscald may occur on transplanted maples, particularly slow growing or suppressed trees which are sometimes transplanted. Only young, vigorous, fast growing sugar maples should be transplanted in order to minimize damage and losses from sunscald.

Insects and Diseases

Insects

Many insects attack and feed on various parts of the sugar maple tree. Fortunately the damage done by most species does not severely reduce sap production.

The group of insects which pose the most serious threat to reduced production, are the defoliating insects. Among the group, the forest tent caterpillar, *Malacosoma dissiria* Hbn. and the saddled prominent, *Heterocampa guttivitta* (Wlk.) are two species which can seriously reduce the sap flow and sap

sweetness in a year following heavy defoliation.

Two other species of defoliators that may be troublesome in sugar bushes, are the Maple leafcutter, *Paraclemensia acerifoliella* (Fitch) and the Bruce spanworm, *Operophtera bruceata* (Hulst). The sugar maple borer, *Glycobius speciosus* (Say) often a troublesome pest of the sugar bush will also be discussed.

Heavy thinning in sugar bushes is not recommended during severe infestations of leaf feeders and defoliators.

Forest Tent Caterpillar

Sugar maple and aspen, (*Populus species*) are the preferred hosts of this insect. Red maple is not attacked. The name is confusing since this caterpillar does not make a tent. The caterpillars spin a silken mat on the trunk or branch where they rest during moulting periods. The adult moths are stout bodied and light brown in colour.

The hairy caterpillar when full grown is about 5 cm (two inches) long. The head and body are generally pale and greyish-blue with orange and black lines. There is a row of yellow or white spots along the back. The caterpillars hatch in the spring and feed until the end of June before spinning a cocoon. They consume most of the foliage.

Maples may be killed when defoliated in successive years. Control of this insect when serious outbreaks occur would have to be done by spraying from aircraft.

The Saddled Prominent

The leaves of sugar maple and beech, *Fagus grandifolia* Ehrh. are favoured food crops of this insect. Most other hardwoods are hosts although green ash, *Fraxinus pensylvannica* Marsh. and white ash *Fraxinus americana* L. are rarely defoliated.

There is considerable variation in the markings of the moths and caterpillars. The female moths have a wingspread of 5 cm (2 inches) and are greenish-brown flecked with white and black splotches. The hairless larvae hatch in late June. Their colours range from yellowish green or light green with a bluish or brownish tint. The back of the body usually has a reddish or purplish saddle-shaped patch.

The larvae feed throughout July, consuming the entire leaf except for the principal veins. Defoliation in combination with drought will intensify damage particularly on trees growing on shallow soils. Normally one defoliation will not kill either the branches or the tree. Successive defoliation may cause some top dieback and tree mortality.

The insect often causes up to three successive years of defoliation. Natural controls such as insect parasites, birds and rodents usually drastically reduce their numbers. Outbreaks can also be terminated by starvation and outbreaks of disease. When serious outbreaks occur, the insect should be controlled by aerial spraying.

Maple Leafcutter

The maple leafcutter is easily recognized by its distinctive feeding habits. Usually the damage caused by this insect is first noticed when the foliage begins to turn light brown in mid to late summer. Close inspection of the damage reveals that parts of the leaf have been mined and small holes have been cut out. This damage can be found on both sugar and black maple as well as a few other species when the insect is numerous.

The maple leafcutter overwinters as a pupa on the ground. Tiny adult moths with bluish front wings and a yellow head emerge in May when the leaves commence to grow.

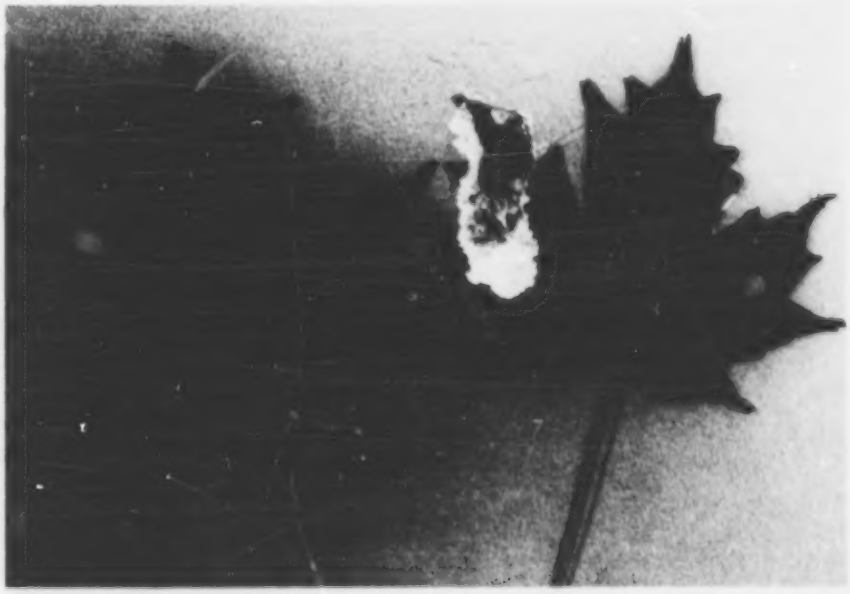
The eggs are laid singly in pockets cut into the undersurface of the leaves. They hatch in about 18 days and the young larvae spend the first part of their feeding in mines in the inner leaf tissue. The larvae complete their mining phase right after the first moult.

At that time they leave the mine in a portable case fashioned by cutting a pair of oval discs, one each from the lower and upper surface of the mine, and tying them together with silk.

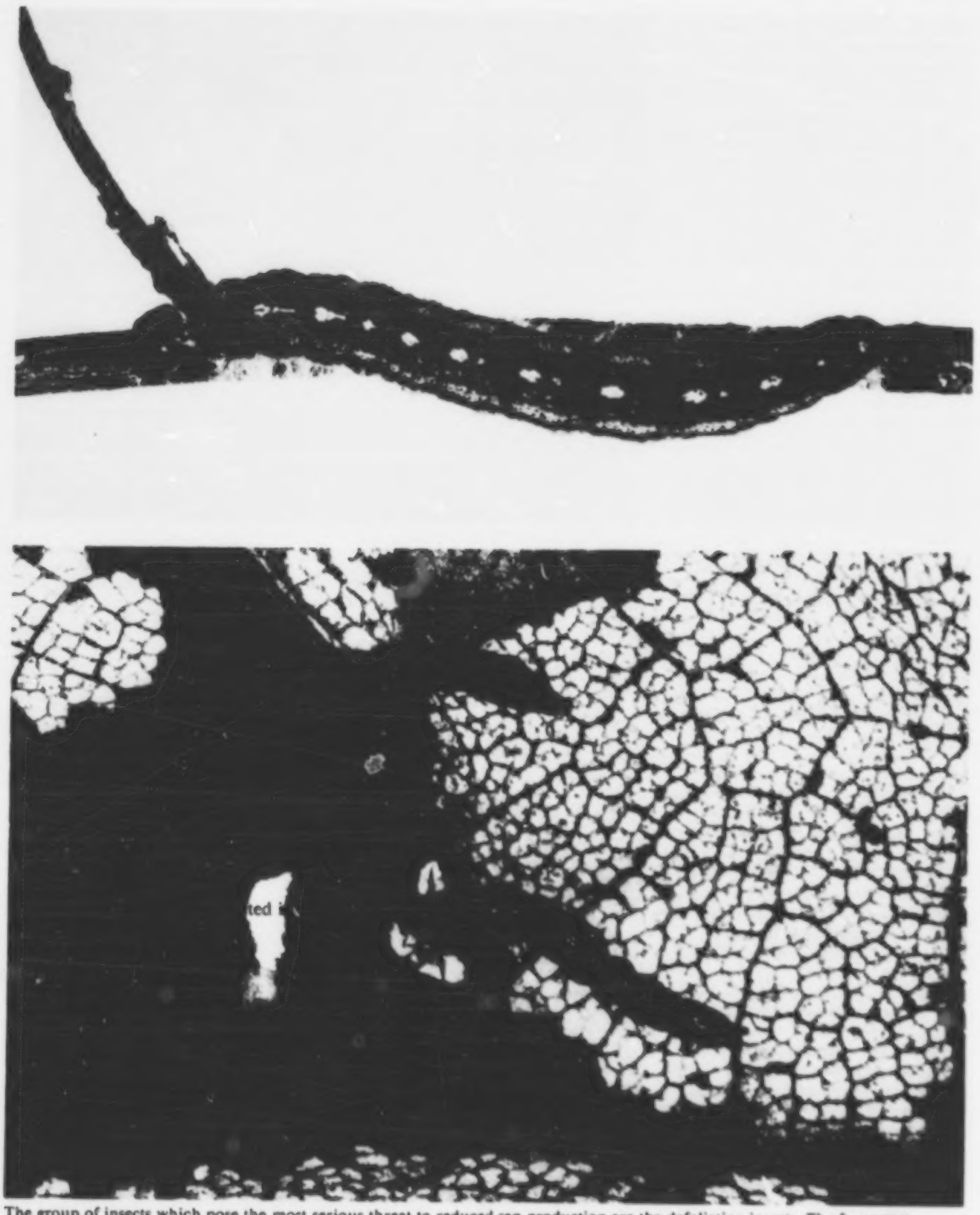
This protective shelter is joined on the upper surface of the leaf. From it the larva reaches out and feeds in a circle on the nearby upper layer of cells. The uneaten center drops out leaving a hole in the leaf. Continuous feeding by several larvae results in many holes in a leaf by the time larval feeding is completed. In the late summer the larva drops with its case and overwinters as a pupa on the ground. At this time the insect is only about 6 mm ($^1/_4$ inch) in length.

This insect is sometimes found in sugar bushes and heavy infestations of it may be of prolonged duration. Repeated severe attacks of this insect will reduce tree vigour and the sugar content of sap.

Maple syrup producers experiencing problems with this insect should contact a local forester for advice concerning control.



Damage to leaves caused by the maple leafcutter.



The group of insects which pose the most serious threat to reduced sap production are the defoliating insects. The forest tent caterpillar, top and the saddled prominent, bottom, are both in this group.
Photos by: Canadian Forestry Service.

Bruce Spanworm

Periodically infestations of the Bruce spanworm are troublesome in sugar bushes. The insect is a defoliator of a variety of species of trees, but prefers maple, beech and aspen. Large widespread infestations of this insect have occurred. They usually last about three years, then collapse.

The small orange eggs are laid singly or in small groups in the fall in lichens or bark nitches on the lower trunk and larger branches of trees. In the spring the eggs hatch and the larvae climb the tree to feed on the leaves.

When disturbed they spin down from the tree on silken threads and when the threads break they may be carried for long distances by wind. This is the main means of dispersal for the insect since the female is wingless.

The larvae are pale yellow green to dark brown in colour.

They have distinct white lines on their back and sides. The Bruce spanworm feeds for 5 to 7 weeks, cutting numerous holes in the leaves. When heavy feeding occurs most of the leaf is consumed. The full grown larva is about 19 mm ($^{3}/_{4}$ inch) long.

On completion of feeding the larvae drop to the ground and form pupae in cocoons composed of silk, soil and humus particles.

The adults emerge from the pupae following the first heavy frosts in the fall. The winged grey males may even be seen flying near the ground after the snow has arrived. The wingless females crawl up the trunks of trees to mate and lay their eggs.

There are a large number of parasite species that attack this insect. However a virus disease is the most important factor in bringing about the collapse of a heavy infestation. Spraying to control this insect is not usually necessary.

The Sugar Maple Borer

The sugar maple borer attacks the bole and large branches of the sugar maple. New attacks may be detected by small areas of discoloration or by presence of frass or sawdust on the bark. Usually new attacks are not noticed. Following the attack, the bark in the infected area will loosen and areas of cracked bark will

(Above) Damage to leaves caused by the Bruce spanworm.

(Below) Sugar maple borer damage. The larval gallery appears as a shallow groove cut in the outer sapwood.

Maple trees weakened by decay following an attack by the sugar maple borer are very susceptible to breakage.

appear. A few years later this bark will fall off, exposing the sapwood and larval gallery or galleries.

The maple borer belongs to the Cerambycidae family of beetles, which are commonly referred to as long horned beetles. The adult is black with yellow markings and has two long antennae. The adult does not damage the tree. Unfortunately most of the two year life span of this insect is spent in the larval stage. It is the larva of the sugar maple borer that causes serious damage to the tree.

The larval galleries appear as shallow grooves or channels cut in the outer sapwood. The galleries do not usually extend around the entire perimeter of the bole and therefore the tree is not killed. The damage is usually confined to the lower 6 metres (20 feet) of the bole. Trees measuring less than 15 cm (6 inches) in diameter at breast height are seldom attacked. The beetles are sunloving and the most extensive and successful attacks follow heavy thinnings or long term grazing in maple stands. In addition the attacks are most commonly found on the south side of the boles of trees of low vigour. Shallow and dry soils tend to create conditions which reduce tree vigour and favour borer attack following heavy thinning.

Diseases

Heart Rots

Heart rots in living trees in the sugar bush are often encountered. There are several fungi which cause

(Top) A fungus conk on a tree trunk is an indication of advanced heart rot or decay within the tree.

(Above) Eutypella canker on sugar maple. Severely infected trees should be removed.

heart rot. They enter the tree through wounds, frost cracks, dead branch stubs or tapholes. Heart rot occurring at the base of a tree is called butt rot. The presence of advanced heart rot in a tree may be indicated by the presence of external growths such as mushrooms or conks.

Polyporus glomeratus Peck, commonly called Spongy Rot, is the most common heart rot fungus of sugar maple. Other species of rot fungi found in sugar maple are the yellow cap fungus, *Pholiota* sp.; the spine tooth fungus, *Hydnum septentrionale* Fr.; the false tinder fungus, *Fomes igniarius* (L.) Gill.; the mossy top fungus, *Fomes connatus* (Weinm) Gill.; and the shelf fungus, *Fomes applanatus* (Pers.) Gill.

A root rotting fungus, *Armillaria mellea* (Vahl.) Quel. commonly known as the shoestring root rot will attack sugar maple trees of low vigour.

Grazing livestock, logging and fires may damage trunks, allowing entry of fungus spores. To minimize damage to remaining trees, sugar bush owners should take extra precautions when thinning. Damage caused by falling trees and logging equipment provides ready access for fungus infection.

Losses from decay will be minimized if trees are kept free of wounds. Over-tapping may also contribute to increased losses due to heart rot.

Canker Diseases

Two canker diseases are often found in the sugar bush. They are: eutypella canker, *Eutypella parasitica* Davids. and Lorenz and nectria canker, *Nectria galligena* Bres. These cankers are both perennial and once established will significantly weaken the trunks of sugar maples.

Eutypella Canker

Eutypella canker develops only on the lower trunks of sugar maple, red maple and box-elder, *Acer negundo* L. The fungus causing the canker usually enters through a dead branch stub. This canker usually retains the dead bark. Concentric zonation is common and considerable distortion of the trunk is often evident. White to buff mycelial fans develop under the bark near the edge of cankers, and the sapwood decays. Infected trees in the 2-8 cm (1"-3") diameter classes are often killed. Larger trees are seldom killed even though cankers may extend up to 1.5 metres (5 feet) in length. Eutypella cankers can weaken the trunks of the maples considerably. Often infected trees are broken off in windstorms.

Nectria Canker

This canker disease is characterized by sunken areas on the trunk or limbs. The cankered area is usually concentric or target-shaped in appearance. The fungus enters the tree through wounds, frost cracks, and cracks at branch axils.

Young trees with cankers should be removed when thinning. Older infected trees should be removed, particularly when the damage is extensive enough to significantly weaken the trunk of the tree.

Maple Decline

Maple decline is a disease which appears to be associated with a variety of infectious and noninfectious factors.

Maple decline will be first noticed as an abnormal leaf condition. In August premature leaf coloration and leaf fall may be noticed from a few branches. As the disease continues, twigs and branches of increasing size will die.

There are many environmental and biological factors that cause stress in maple trees and result in maple decline. Often these stress factors combine to cause the dieback and resultant death of trees.

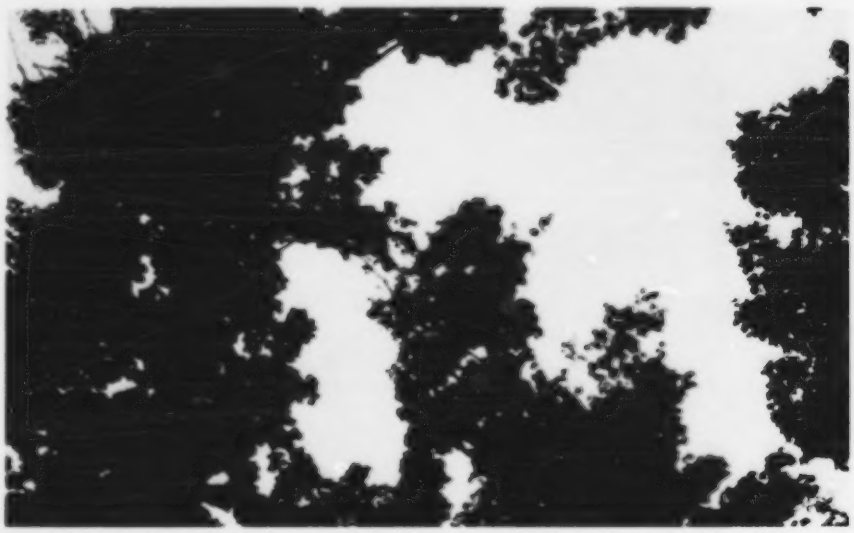
Some factors contributing to maple decline in the sugar bush are as follows:

1. Overmature trees
2. Root, stem and branch defects which involve rots, decays and/or cankers.
3. Drought, particularly recurring droughts.
4. Heavy defoliation by insects, eg. tent caterpillar, saddled prominent.
5. Restricted rooting depth
   - shallow soil over bedrock
   - compacted layers in the soil impervious to roots
   - high summer water table
6. Excessive exposure of old growth or suppressed trees following thinning, blowdown etc.
7. Winter injury, frost cracks, bud and twig mortality
8. Mechanical damage to bark resulting in decay.
9. Overstocking – high density of trees
10. Grazing by livestock
11. Marginal site for healthy and vigorous sugar maple growth
12. Low soil fertility (nutrient deficiencies)
13. Improper tapping
14. Air pollution

During periods of drought, particularly recurring droughts and/or heavy defoliation, the disease is favoured and becomes more serious and widespread.

Good management of the sugar bush will help to minimize stress factors by providing good conditions for vigorous tree growth. Furthermore, trees likely to suffer from maple decline such as overmature or defective trees will be removed in successive thinning operations thus reducing the incidence of maple decline.

The Ontario Ministry of the Environment is currently conducting research studies to determine the level of significance of acid rain as a contributing factor to maple decline.



Maple decline in old growth sugar bush following thinning.

Young sugar maple girdled and killed by a porcupine.

Porcupine den in old growth sugar maple. In productive sugar bushes dens should be removed.

Wildlife

Porcupines

Porcupines may do considerable damage by girdling sugar maple branches and stems. Severely damaged trees may die as a result of porcupine feeding. Porcupines are found throughout the entire commercial range of the sugar maple.

Normally the porcupine feeds on small trees, shrubs and herbaceous vegetation. However, during the winter months, porcupines often feed heavily on the bark of large trees. Sugar maple bark is one of their preferred winter foods.

Control of porcupines in the sugar bush by hunting is relatively easy. Sugar bush owners should make a thorough inspection of their woodlot to locate porcupine dens. Porcupines den in hollow trees and logs or in caves among rocky outcrops. Dens may be high in trees or at ground level. Where possible dens should be removed. Normally porcupines do not venture far from their dens to feed. Therefore precautions against porcupine damage are only necessary within the sugar bush and along its perimeters.

Light damage caused by mice or voles 2 years ago. The damage is already partially healed over.

Fresh damage to young thin barked sugar maple. Trees like this one which are completely girdled will die.

Squirrels and Chipmunks

Black and red squirrels and chipmunks may cause considerable damage to plastic tubing sytems. They will puncture and chew tubing as well as plastic spiles and fittings. Severe damage to tubing by squirrels normally occurs only periodically and therefore attempting to eliminate all squirrels and chipmunks in the sugar bush is not the answer. The best method for controlling them involves manipulation of the habitat, particularly removal of trees from the sugar bush which provide food. White oak acorns and bitternut hickory nuts are two preferred foods of squirrels. Removal of these trees along with other nut producing species such as beech and butternut will reduce the squirrel population in the bush.

Lateral line tubing left in the sugarbush may be damaged at any time of the year by squirrels, chipmunks and other wildlife species. Taking it down and storing it away during the off-season minimizes the incidence of damage to it. In the spring of the year squirrels may be seen clipping twigs, eating buds and drinking sap from clipped maple branches. This damage is not usually serious.

Mice and Voles

Damage caused by mice and voles in the sugar bush is not usually serious. They feed on the thin bark of the young maples during the winter under snow. The damage usually goes unnoticed until the snow goes away in the spring. Trees which are completely girdled will die.

Their population is cyclical. The most extensive damage occurs in

years when the population is high. During years of high population, sugar bush owners should protect young maples by distributing one of the commercially prepared mousebaits in the bush.

In maple plantations protective guards should be placed around the base of each tree to prevent damage.

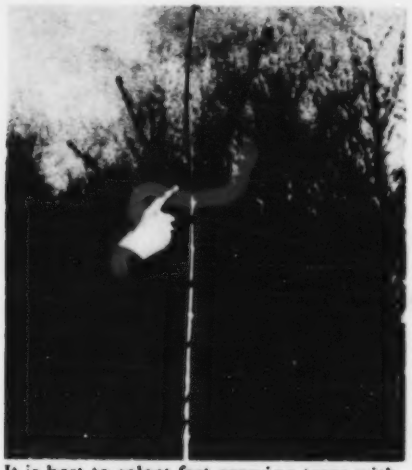
Transplanting Sugar Maples For Maple Syrup Production

Small maple plantation set out in 1941. Note the development of deep broad crowns which are ideal for sap production.

When the selected tree has a double leader, remove one leader by pruning.

The successful management of a maple business involves careful long term planning. Maple producers who desire an immediate increase in production of maple products may do so by renting or leasing neighbouring sugar bushes. Those wishing a gradual increase in production may do so by the application of wise sugar bush management practices and by transplanting.

The survival and growth of young maples will depend on choosing a suitable site for the plantation. Sugar maple grows best on deep, fertile, moist well drained loam soils with a pH of 5.5 to 7.3. It does grow on poor, shallow or sandy soils but growth is slow. These sites would be less suitable for plantations since rapid growth of the transplants is desirable.



It is best to select fast growing trees with single leaders. Leader growth should be at least 30 cm (1 foot) per year.

It is very important to transplant only healthy fast growing trees since survival and growth of these trees is far superior to older, suppressed trees that have been removed from shady, overcrowded woodlots. Also the incidence of sunscald damage is minimized if fast growing young trees are transplanted.

The following procedure is recommended for transplanting sugar maples ranging in diameter from 12 to 25 mm ($^1/_2$ to 1 inch) and from 1.2 to 3.0 metres (4 to 10 feet) in height. These trees, when transplanted to a suitable site, should be ready for tapping about 25-30 years after transplanting.

However, when conditions are ideal, trees may reach tapping size in about 20 years.

Procedure to Follow When Transplanting Sugar Maples

1. For best results transplant sugar maple trees in the spring as soon as the frost is out of the ground. Transplanting should be completed before the buds begin to burst. Sugar maple may also be transplanted in the fall after the leaves have dropped.
2. Select open grown trees or trees growing at the edge of the woodlot. These trees will be younger and growing faster than those found under shade in the woodlot. Fast growing young trees may also be selected from openings in the woodlot made in previous thinnings.
3. Select fast growing trees showing growth on the leader of at least 30 cm (1 foot) per year. Flat topped trees or those without a central leader are less desirable.
4. Select straight vigorous trees that are free of stem defects. Select and tag good quality trees in advance.
5. Select trees ranging in diameter from 12 to 25 mm ($^1/_2$ to 1 inch) and in height from 1.2 to 3.0 metres (4 to 10 feet).
6. In preparing the tree for lifting, drive a spade or shovel into the ground about 20 – 25 cm (8 – 10 inches) deep in a circle 30 cm (1 foot) from the stem of the tree. This will sever the large roots running away from the base of the tree.
7. Work the shovel downwards and inwards to loosen the tree for lifting.
8. Using the shovel, lift the tree, being careful not to let the soil fall off the roots. If the soil falls off the roots do not discard the tree because it may still survive when transplanted.
9. Wrap the roots and earth in burlap to hold the soil on the roots. Tie the burlap securely around the base of the stem.
10. Select a deep, fertile, moist but well drained loam or sandy loam soil for the planting site.
11. Holes should be dug large enough to accommodate the root ball.
12. Place the root ball in the hole and untie the burlap. It is not necessary to remove it unless it is to be used again.
13. The planting hole should be deep enough so that the tree can be planted at the same level as it was previously.
14. Replace earth to fill the area around the perimeter of the ball and pack firmly with the heel.
15. For best growth and survival, fertilizer should be used. Fertilization may be carried out as follows:

(a) Slow release fertilizer tablets may be inserted in the planting hole at the time of planting. These slow release tablets will feed roots for up to two years. Do not place the tablets in the bottom of the planting hole. Backfill about halfway around the root ball, then insert the tablets. The number of tablets used per

tree depends on the grade of fertilizer, the weight of the tablet, and the size of the tree. Manufacturers recommendations should be followed.

(b) If dry commercial fertilizer is to be used it should not be applied until early in the spring following transplanting. The fertilizer should be spread on the ground at the perimeter of the planting hole. Apply 0.57 litre (1 pint) of fertilizer for every 2.5 mm (1 inch) in diameter of the tree stem. It is recommended that a balanced fertilizer such as 10-10-10 be used.

(c) Well-rotted barnyard manure applied in late fall or early spring would be beneficial to the maple transplants if commercial fertilizers are not used.

16. If only one row of trees is planted, they should be placed about 9.1 metres (30 feet) apart. If several rows are planted about 250 trees per hectare (100 trees per acre) is desirable. If the trees are planted 6.4 metres (21 feet) apart in the rows and the rows are 6.4 metres (21 feet) apart, approximately 250 trees per hectare (100 trees per acre) are required.

17. Normally in the early spring when maples are transplanted, the soil is moist and watering is unnecessary. When the weather is very dry following transplanting, the trees should be watered at least once a week.

18. The newly planted maples should be given some artifical support to prevent excessive swaying and breakage. A strong stake 1.8 to 2.4 metres (6 to 8 feet) in length should be driven into the ground near the base of the tree. A short length of garden hose with a wire running through it can be used to secure the tree to the stake. The garden hose will protect the bark from damage.

19. It is desirable to prune each tree so there will be a more favourable balance between the roots and crown. To avoid loss of sap, pruning should not be carried out in the spring immediately after transplanting. Pruning should be carried out in late spring after the new leaves are partly formed. When pruning the average tree, side branches should be cut back about one third. Do not cut the leader. When the selected tree has acute forking and a double leader, remove one leader by pruning.

In preparing the tree for lifting, drive a spade or pointed shovel into the ground about 20-25 cm (8-10 inches) deep in a circle 30 cm (1 foot) from the stem of the tree. This will sever the large roots running away from the tree.

20. Control of grass and weeds for planting is recommended. Ploughing and cultivating the site before planting is recommended if soil conditions permit. Cultivation should be carried out for about three years after transplanting.

When cultivation is not possible, control of grass and weeds in a 0.9 to 1.2 metre (3 to 4 foot) circle is recommended for a couple of years following transplanting. This is usually done by applying a herbicide such as simazine.

21. The thin bark of young sugar maples is a desirable winter food of both rabbits and mice. It is recommended that each tree be protected by applying plastic, aluminum foil or other protective guards around the lower portion of the stem. Be sure that the guards are long enough to extend above the snow line. Commercially prepared mouse bait may also be applied during the fall of the year to control mice and reduce damage.

When maples smaller than 12 mm ($^1/_2$ inch) in diameter are transplanted, it is not necessary to remove a ball of earth with the roots. However, care must be taken to prevent the roots from drying. Weed and grass control is particularly important when small stock is being transplanted.

Tree guards should be installed on transplanted maples in the late fall. They are especially required when thick grass is present. Be sure the guards are long enough to extend above the snow line.

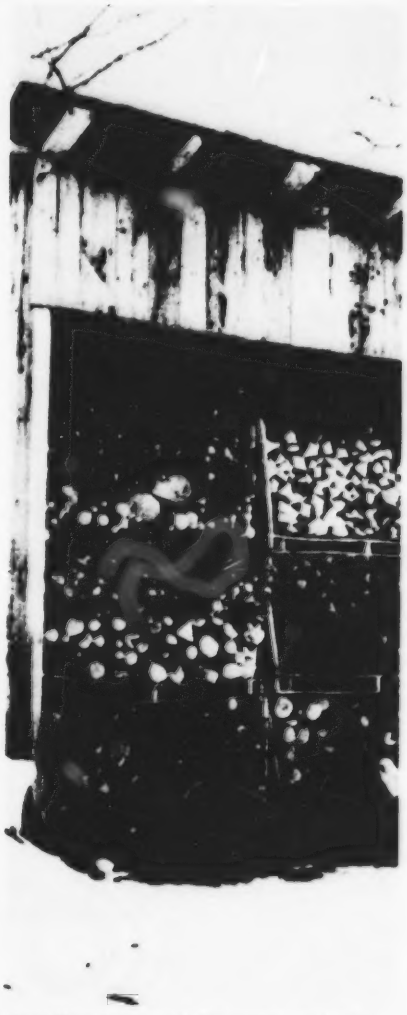
When transplanting larger trees over 2.5 cm (1 inch) in diameter, trenching is necessary to provide for the removal of the root ball.

When maples larger than 2.5 cm (1 inch) in diameter are transplanted, a larger ball of earth should be taken with the tree in order to ensure successful transplanting. Trenching to provide for removal of the root ball is necessary. It is generally recommended that the root ball be 30 cm (1 foot) in radius for each 2.5 cm (inch) in diameter of the stem for trees from 2.5 to 7.6 cm (1 to 3 inches) in diameter. Front end loaders on farm tractors are particularly useful for moving larger trees.

Wood Utilization, Harvesting And Sale of Wood from The Sugar Bush

(Top) Wood removed in a thinning from a managed woodlot. This wood will be cut into 40 cm (16 inch) lengths and sold as fireplace wood in a nearby town.

(Above) The sugar bush supplies the fuelwood for evaporating in many maple syrup operations.



Handling fuelwood on pallets reduces the labour involved in moving wood. For maximum heating efficiency, only seasoned wood should be burned.

The prime objective of the maple producer should be to maximize production of maple sap from the woodlot on a sustained yield basis. Efforts to do this will involve the removal of timber in the thinnings which should be utilized or sold to help reduce production costs for maple syrup.

Fuelwood

Wood is still a major source of fuel on many farms in Ontario. Many use wood for heating homes, cooking and to fire sap evaporators. A cubic metre of wood is equivalent to a pile of 1 metre wood stacked one metre high and one metre in length occupying a space of one cubic metre. Of this approximately 0.67 cubic metres is wood fibre, the rest is airspace and bark. (A standard cord of wood is equivalent to a pile of 4 foot wood stacked 4 feet high and 8 feet in length occupying a space of 128 cubic feet. Of this approximatley 85 cubic feet is wood fibre, and the rest is airspace and bark.)

Only well seasoned wood should be burned. Green wood may contain over 100 per cent moisture in relation to its bone dry weight, while air dry or seasoned wood contains approximately 20 per cent moisture. Therefore, the heating value of a cubic metre (cord) of green wood is less than seasoned wood. Fuelwood over 20 cm (8 inches) in diameter should be split so that it will season more rapidly.

It takes approximately one cubic metre (one standard cord) of seasoned hardwood for every 21 (75) tapholes to do the boiling. Wood cut and split during the fall and winter and piled in the open should be well seasoned one year later. Fuelwood should not be piled in the woodlot for seasoning. If possible cover the wood-pile or pile the wood in a shed with open sides.

Fuelwood 0.9 to 1.2 metres (3 to 4 feet) long is more readily handled if pallets are used. For best results wood should be split in the bush using a hydraulic wood splitter, piled

provide easy access to all parts of the

may result in an increased summer

Removal of logs, pulpwood and fuelwood provides secondary cash returns from the sugar bush.

(Top) Good markets for hardwood sawlogs and veneer logs are available for logs removed in thinnings.

(Above) Small wheeled timber skidders can be used when carrying out thinning operations. Careful use of them is essential.

on pallets and then moved to a storage shed.

The heating value of air dry wood varies by species. Those species with the highest heating value are usually the heaviest. The following chart shows the gross heating value for many native tree species.

Heating Value of Some Native Species of Wood

Species	Gross Heating Value for Air Dry Cubic Metre (Joules)	Gross Heating Value for Air Dry Standard Cord (BTU'S)
Rock Elm	8372	32,000,000
White Oak	8006	30,600,000
Bitternut Hickory	7639	29,200,000
Sugar Maple	7587	29,000,000
Beech	7273	27,800,000
Red Oak	7142	27,300,000
Yellow Birch	6855	26,200,000
White Ash	6541	25,000,000
White Elm	6410	24,500,000
White Birch	6122	23,400,000
Hemlock	4638	17,900,000
White Pine	4474	17,100,000
White Cedar	4265	16,300,000

Many farmers living close to large urban centres have found lucrative markets for fireplace wood. Fireplace wood is normally sold by the single or face cord in small quantities. It usually brings a high price when sold in this manner.

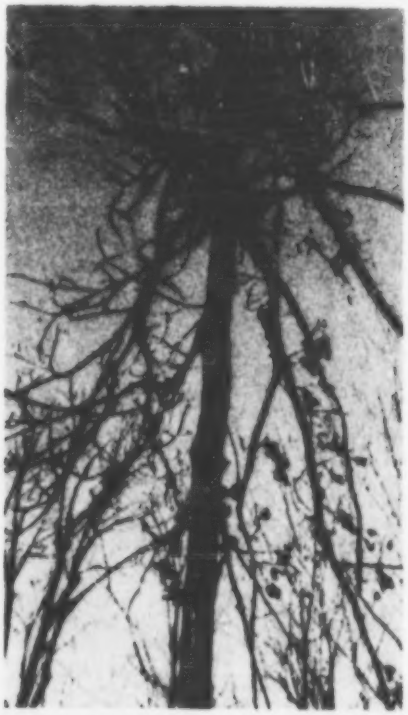
Sawlogs, Veneer Logs, and Pulpwood

The main source of income from the tapped sugar bush will be from maple syrup and related products. Secondary income can be obtained from the sale of sawlogs, veneer logs, and pulpwood. This wood will be removed in thinnings or improvement cuts which are designed to improve the sugar bush for maple sap production.

The staining in the sapwood and heartwood caused by the tapholes lowers the log grade of the butt portion of the tree.

Careless logging causes unnecessary damage to remaining trees.

This modern farm tractor is equipped with a three point hitch logging attachment for winching and skidding.



Trees with severe top damage resulting from a logging operation should be removed and utilized since they will not make good crop trees.

Trees to be removed in thinnings or improvement cuts are discussed in detail in this publication.

Timber Harvesting

Most woodlot jobbers in Ontario use articulated wheeled skidders for timber extraction. The size of these machines varies considerably. The smaller ones are best suited for selective logging in sugar bushes. They are highly manoeuverable and when driven by a competent operator will do a satisfactory job.

With improved hydraulics, protective cabs and attachments for logging, farm tractors are also suitable for selective logging. When thinning a woodlot it is very important to minimize damage to remaining sugar maple crop trees.

With that in mind the following points should be considered:

1. Carefully plan the felling of each tree. Use wedges when necessary.
2. Fell the trees with the tops away from the skid trail. This provides for easier choking and less damage by swing.
3. Back the tractor or skidder where feasible to avoid turning around in the bush. Turning often causes considerable damage to young trees.
4. To minimize damage to young trees use the winch to pull logs through them.
5. Be careful not to overload the tractor or skidder when skidding timber.
6. Use the existing road system wherever possible for skid trails.

Ten Important Points to Remember When Making A Timber Sale From The Sugar Bush

1. Locate and mark the timber boundaries.
2. Mark the individual trees which should be harvested.
3. Always get bids from several buyers before selling.
4. Always sell timber with a written contract; have your family lawyer draw up the contract.
5. Use the harvest methods that will improve your stand and increase sap production from your woodlot.
6. Sell to a reputable individual or firm that has experience in thinning sugar bushes.
7. Make it clear to the jobber that every precaution must be taken to minimize damage to trees not being harvested. A clause should be contained in the contract that gives the owner the right to order complete cessation of the thinning operation at anytime, if in his judgement, damage to remaining trees is excessive and not acceptable. Make frequent inspections to check on the quality of the work while cutting is in progress.
8. Investigate wood specialty markets, e.g. white ash – handles; black walnut – furniture.
9. Never rush into signing a contract for the sale of timber; if you do, you may be sorry at a later date.
10. Contact a Ministry of Natural Resources forester or a consultant forester for advice.

Sugar Bush Management Assistance Available to Ontario Maple Syrup Producers

Sugar Bush Advisory Service

The ministry may provide up to 4 days of free advisory service to sugar bush owners requesting assistance for the management of their woodlot.

Advice is available on thinning, tapping, transplanting sugar maples, tree marking and woodlot protection. Advice on calculating the tapping potential of untapped woodlots is also available.

Trees that should be harvested in sugar bushes can be marked by Ministry staff and assistance in locating suitable timber buyers is offered.

For those wishing to establish new maple plantations by transplanting, advice is available concerning location of planting sites, soil type, spacing, etc.

Sugar Bush Assistance Service

The Woodlands Improvement Act of 1966 enables the Ministry of Natural Resources to enter into long term agreements with landowners who have woodlots suitable for improvement.

Agreements can be made with maple syrup producers and potential producers who have upland hardwood woodlots suitable for improvement. The improvement involves thinning of the woodlot to improve growing conditions for select sugar maple crop trees. Under the terms of the agreement, woodlot owners can be paid at least in part to carry out the work as prescribed in the management program, provided the timber to be removed is not saleable as stumpage.

The work involves removal of marked trees by cutting, lopping or girdling. A minimum of 2 hectares (5 acres) of woodland is required to qualify for assistance and the term of the agreement is normally 15 years.

Improvement Programs

Thinning the Young Sugar Bush in Preparation for Tapping

Agreements can be made with landowners who own young hardwood woodlots containing an abundance of sugar maple.

Management will favour the growth of up to 250 crop trees per hectare (100 crop trees per acre) by the removal of trees adjacent to them. Thinning will permit room for expansion of the crowns of crop trees and reduce the competition for moisture and nutrients in the soil. The result is that the growth rate of the crop trees is increased and the trees will reach the tapping diameter of 25 cm (10 inches) at an earlier date.

Thinning the Tapped Sugar Bush to Increase or Maintain Sap Production

Agreements can be made with maple syrup producers for improvement of woodlots presently being tapped.

The management recommendations will be directed at producing and maintaining a high sustained yield of sweet sap from the sugar bush. Management in these stands will normally consist of removal of low yielding or non-sap producers to provide additional growing space for select maple crop trees. Where necessary, larger openings in the stand will be prescribed to encourage natural maple regeneration.

Owner's Obligations

The owner is responsible for the protection of the woodlot from livestock, insects and disease, fire, etc. The owner will be required to fence woodlots when livestock is pastured adjacent to the agreement area.

For further information or assistance, sugar bush owners should contact their local district office of the Ministry of Natural Resources

See Appendix F.

The Ontario Maple Syrup Producers Association

The Ontario Maple Syrup Producers Association is an organization devoted to the development, expansion and improvement of the maple syrup industry in Ontario. The membership comprises both maple syrup producers and others interested in the maple industry.

The Association was founded in 1966. It operates under a Charter dated October 2, 1970 from the Ontario Ministry of Agriculture and Food. There are eleven branches of the association. They are as follows:

Algoma and District
Lanark and District
Quinte District
Algonquin District
Grey, Bruce and District
South Western Ontario
Eastern Counties
Renfrew and District
Haliburton Highlands District
Simcoe and District
Waterloo and District

The Board of Directors is composed of two directors from each district and the secretary-manager of the Ontario Maple Syrup Producers Association. Each year five directors' meetings are held. In addition an annual meeting is held in the fall. During the winter months an information meeting is held in each district.

There is an increasing interest in the association. From its formation the membership has increased to 600 in 1986. Members of the association are informed of modern methods of maple production through the *Maple Newsletter*, which is issued by the association several times annually. Members also receive the Maple Syrup Digest.

To promote Ontario maple products booths are set up at major exhibitions, fall fairs, and ploughing matches from which a variety of maple products are sold.

For further information on the Ontario Maple Syrup Producers Association, contact George Sinclair, Secretary Manager, Box 877, Maple, Ontario L0J 1E0.

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Appendix Ai

A GUIDE TO SUGAR BUSH STOCKING* (METRIC)

Table 1

Average crown diameter and minimum number of sugar maple trees per hectare, by average stand-diameter class, for natural sugar bush stands and plantations.

Average stand d.b.h. class	Average crown diameter	Trees per hectare	
		Natural stands	Plantations
Centimetres	Metres	Number	Number
10	5.3	412	358
15	6.1	311	269
20	6.9	242	210
25	7.7	195	168
30	8.5	158	138
36	9.3	133	116
41	10.1	114	99
46	10.9	96	84
51	11.7	84	72
56	12.5	74	64
61	13.4	64	57
66	14.1	57	49
71	14.9	52	44
76	15.8	47	39

* U.S.D.A. Forest Service Research Paper NE-171 Northeastern Forest Experiment Station, Upper Darby, PA.

Table 2

Spacing guide for number of trees per hectare in natural and planted stands of sugar maple.

Trees per hectare			Trees per hectare		
Natural stands	Planted stands	Spacing between trees	Natural stands	Planted stands	Spacing between trees
Number	Number	Metres	Number	Number	Metres
635	548	4.3	101	89	10.7
553	479	4.6	96	84	11.0
484	420	4.9	91	79	11.3
430	373	5.2	86	74	11.6
383	331	5.5	82	72	11.9
343	299	5.8	77	67	12.2
311	269	6.1	74	64	12.5
282	245	6.4	69	62	12.8
257	222	6.7	67	59	13.1
235	203	7.0	64	54	13.4
215	188	7.3	62	54	13.7
198	173	7.6	59	52	14.0
183	158	7.9	57	49	14.3
170	148	8.2	54	47	14.6
158	138	8.5	52	44	14.9
148	128	8.8	49	42	15.2
138	119	9.2	47	42	15.6
128	111	9.4	47	40	15.8
121	106	9.8	44	40	16.2
114	99	10.1	42	37	16.5
109	94	10.4	42	35	16.8

Table 3

Recommended residual basal areas per hectare for natural and planted sugar maple stands.

Average stand d.b.h. class in centimetres	Residual basal area	
	Natural stands sq. metres per ha	Plantations sq. metres per ha
10	3.4	3.0
15	5.7	4.8
20	7.8	6.9
25	9.9	8.5
30	11.5	10.1
36	13.3	11.5
41	14.7	12.8
46	15.8	13.8
51	17.0	14.5
56	18.1	15.8
61	18.8	16.5
66	19.5	17.0
71	20.4	17.7
76	21.3	18.1

Appendix Aii

A GUIDE TO SUGAR BUSH STOCKING (IMPERIAL)

Table 1

Average crown diameter and minimum number of sugar maples trees per acre. by average stand-diameter class, for natural sugar bush stands and plantations.

U.S.D.A. Forest Service Research Paper NE-171 Northeastern Forest Experiment Station, Upper Darby, PA.

Average stand d.b.h. class	Average crown diameter	Trees per acre	
		Natural stands	Plantations
Inches	Feet	Number	Number
4	17.4	167	145
6	20.0	126	109
8	22.6	98	85
10	25.3	79	68
12	27.9	64	56
14	30.6	54	47
16	33.2	46	40
18	35.8	39	34
20	38.5	34	29
22	41.1	30	26
24	43.8	26	23
26	46.4	23	20
28	49.0	21	18
30	51.7	19	16

An ideal plantation would have fewer trees per acre than a sugar bush developed from a natural forest stand. More trees are recommended for a natural stand because the trees are established at random. The area of a hexagon (distance between opposite sides equal to crown diameter) was used to compute number of trees per acre in natural stands. The position of trees in a plantation is fixed by planting in a grid system, so the number of trees per acre in plantations was computed by using the area of a square. (Length of sides equal to crown diameter)

Table 2

Spacing guide for number of trees per acre in natural and planted stands of sugar maple.

Trees per acre			Trees per acre		
Natural stands	Planted stands	Spacing between trees	Natural stands	Planted stands	Spacing between trees
Number	Number	Feet	Number	Number	Feet
257	222	14	41	36	35
224	194	15	39	34	36
196	170	16	37	32	37
174	151	17	35	30	38
155	134	18	33	29	39
139	121	19	31	27	40
126	109	20	30	26	41
114	99	21	28	25	42
104	90	22	27	24	43
95	82	23	26	22	44
87	76	24	25	22	45
80	70	25	24	21	46
74	64	26	23	20	47
69	60	27	22	19	48
64	56	28	21	18	49
60	52	29	20	17	50
56	48	30	19	17	51
52	45	31	19	16	52
49	43	32	18	16	53
46	40	33	17	15	54
44	38	34	17	14	55

Table 3

Recommended residual basal areas per acre for natural and planted sugar maple stands.

Average stand d.b.h. class in inches	Residual basal area	
	Natural stands sq. feet per acre	Plantations sq. feet per acre
4	15	13
6	25	21
8	34	30
10	43	37
12	50	44
16	64	56
18	69	60
20	74	63
22	79	69
24	82	72
26	85	74
28	89	77
30	93	79

Appendix B

Testing Sap Sweetness

The solids (sugar) content of sap can be measured and expressed as °Brix. It is important to know the sap sweetness when choosing crop trees and selling sap. When sap is purchased it is necessary to know its volume in litres (gallons), its density to the nearest $^1/_{10}$° Brix and its temperature to the nearest degree.

The Brix value is read to the nearest 0.1 (degree) on the Brix scale of the hydrometer or refractometer. This is usually just an observed value since the instruments are calibrated to read directly when the sap is 20°C (68°F). When testing sap sweetness no ice should be present in the sap.

The true Brix value is obtained by determining the temperature of the sap using a thermometer and subtracting the correction from the observed Brix value.

Until 1977 the standard density for maple syrup production in Canada was 65.0°Brix.

Now that the legal standard density has been raised to 66.0°Brix, the percentage of sugar in a litre (gallon) of maple syrup is actually 87.2.

For practical purposes however, the rule of 86 used by maple producers is still satisfactory.

Since the solids concentration of sap is comparatively low, its Brix value and percentage of solids (weight-volume) are essentially the same.

Corrections To Obtain True Brix Value

Temperature of Sap in Degrees Celsius	Temperature of Sap in Degrees Fahrenheit	°Brix Correction to Subtract from Observed Brix Value
0 - 5.6	32 - 42	0.4
6.1 - 11.7	43 - 53	0.3
12.2 - 16.7	54 - 62	0.2
17.2 - 18.9	63 - 66	0.1

When the true Brix value of the sap is obtained the *Rule of 86* should be used to determine the number of litres (gallons) of sap required to make a litre (gallon) of maple syrup.

$$\frac{86}{\text{True Brix Value (sugar content of Sap)}} =$$

Number of litres (gallons) of sap required to make one litre (gallon) of standard density maple syrup.

Appendix C

CUBIC METRE VOLUME TABLE FOR STANDING TIMBER
A Quick Method of Estimating Approximate Volume of Standing Timber (Based on Smalian's Formula, Form Class #79)

DBH	MERCHANTABLE LENGTHS (METRES)								
cm	2	3	4	5	6	7	8	9	10
20	0.0392	0.0588	0.0784	0.0980	0.1169	0.1343	0.1503	0.1649	0.1782
22	0.0474	0.0712	0.0949	0.1186	0.1415	0.1626	0.1821	0.2000	0.2163
24	0.0565	0.0847	0.1129	0.1412	0.1684	0.1937	0.2170	0.2384	0.2581
26	0.0663	0.994	0.1325	0.1657	0.1977	0.2274	0.2549	0.2802	0.3035
28	0.769	0.1153	0.1537	0.1921	0.2292	0.2637	0.2958	0.3253	0.3525
30	0.0882	0.1323	0.1765	0.2206	0.2632	0.3029	0.3398	0.3739	0.4053
32	0.1004	0.1506	0.2008	0.2510	0.2996	0.3449	0.3871	0.4263	0.4625
34	0.1133	0.1700	0.2267	0.2833	0.3382	0.3896	0.4376	0.4822	0.5237
36	0.1271	0.1906	0.2541	0.3176	0.3792	0.4370	0.4911	0.5415	0.5884
38	0.1416	0.2123	0.2831	0.3539	0.4225	0.4870	0.5473	0.6037	0.6561
40	0.1569	0.2353	0.3137	0.3921	0.4682	0.5396	0.6066	0.6691	0.7274
42	0.1729	0.2594	0.3459	0.4323	0.5162	0.5952	0.6693	0.7386	0.8033
44	0.1898	0.2847	0.3796	0.4745	0.5667	0.6536	0.7352	0.8117	0.8833
46	0.2074	0.3112	0.4149	0.5186	0.6194	0.7146	0.8042	0.8883	0.9671
48	0.2259	0.3388	0.4517	0.5647	0.6746	0.7784	0.8763	0.9683	1.0547
50	0.2451	0.3676	0.4902	0.6127	0.7320	0.8448	0.9514	1.0518	1.1461
52	0.2651	03976	0.5302	0.6627	0.7918	0.9141	1.0296	1.1387	1.2413
54	0.2859	0.4288	0.5717	0.7147	0.8540	0.9860	1.1110	1.2291	1.3404
56	0.3074	0.4612	0.6149	0.7686	0.9185	1.0607	1.1955	1.3229	1.4431
58	0.3298	0.4947	0.6596	0.8245	0.9853	1.1381	1.2830	1.4202	1.5498
60	0.3529	0.5294	0.7058	0.8823	1.0545	1.2182	1.3736	1.5209	1.6601
62	0.3768	0.5653	0.7537	0.9421	1.1260	1.3010	1.4673	1.6250	1.7743
64	0.4015	0.6023	0.8031	1.0039	1.1999	1.3866	1.5642	1.7327	1.8924
66	0.4270	0.6406	0.8541	1.0676	1.2762	1.4749	1.6640	1.8437	2.0141
68	0.4533	0.6800	0.9066	1.1333	1.3548	1.5660	1.7671	1.9583	2.1397
70	0.4804	0.7205	0.9607	1.2009	1.4356	1.6597	1.8731	2.0762	2.2691
72	0.5082	0.7623	1.0164	1.2705	1.5189	1.7561	1.9823	2.1976	2.4023
74	0.5368	0.8052	1.0737	1.3421	1.6046	1.8554	2.0946	2.3225	2.5393
76	0.5662	0.8494	1.1325	1.4156	1.6925	1.9573	2.2099	2.4508	2.6801
78	0.5964	0.8947	1.1929	1.4911	1.7829	2.0619	2.3284	2.5826	2.8247
80	0.6274	0.9411	1.2548	1.5685	1.8755	2.1692	2.4499	2.7178	2.9730
82	0.6592	0.9888	1.3184	1.6479	1.9705	2.2793	2.5746	2.8565	3.1252
84	0.6917	1.0376	1.3835	1.7293	2.0679	2.3922	2.7023	2.9986	3.2813
86	0.7251	1.0876	1.4501	1.8126	2.1676	2.5077	2.8332	3.1442	3.4410
88	0.7592	1.1388	1.5183	1.8979	2.2698	2.6264	2.9680	3.2949	3.6072
90	0.7941	1.1911	1.5881	1.9852	2.3743	2.7479	3.1060	3.4490	3.7771
92	0.8298	1.2446	1.6595	2.0744	2.4812	2.8719	3.2468	3.6061	3.9500
94	0.8662	1.2993	1.7325	2.1656	2.5903	2.9984	3.3900	3.7656	4.1252
96	0.9035	1.3552	1.8070	2.2587	2.7017	3.1275	3.5364	3.9285	4.3041
98	0.9415	1.4123	1.8830	2.3538	2.8156	3.2598	3.6866	4.0962	4.4889
100	0.9803	1.4705	1.9607	2.4508	2.9319	3.3949	3.8401	4.2679	4.6783

CUBIC METRE VOLUME TABLE FOR STANDING TIMBER (Cont'd)
A Quick Method of Estimating Approximate Volume of Standing Timber (Based on Smalian's Formula, Form Class # 79)

MERCHANTABLE LENGTHS (METRES)

11	12	13	14	15	16	17	18	19	20
0.1922	0.2035	0.2137	0.2226	0.2304	0.2471	0.2537	0.2591	0.2634	0.2665
0.2341	0.2484	0.2612	0.2727	0.2828	0.3029	0.3116	0.3189	0.3248	0.3294
0.2802	0.2977	0.3136	0.3279	0.3406	0.3644	0.3755	0.3849	0.3927	0.3991
0.3304	0.3515	0.3707	0.3881	0.4038	0.4315	0.4453	0.4571	0.4672	0.4755
0.3847	0.4097	0.4325	0.4534	0.4724	0.5043	0.5210	0.5356	0.5481	0.5587
0.4432	0.4724	0.4993	0.5240	0.5465	0.5793	0.5987	0.6158	0.6309	0.6439
0.5059	0.5396	0.5708	0.5996	0.6259	0.6671	0.6906	0.7114	0.7297	0.7456
0.5726	0.6112	0.6470	0.6802	0.7107	0.7570	0.7843	0.8087	0.8303	0.8491
0.6435	0.6873	0.7281	0.7659	0.8009	0.8533	0.8848	0.9130	0.9382	0.9604
0.7185	0.7679	0.8140	0.8569	0.8966	0.9581	0.9943	1.0270	1.0563	1.0824
0.7976	0.8526	0.9039	0.9515	0.9956	1.0690	1.1103	1.1477	1.1814	1.2116
0.8810	0.9424	1.0000	1.0539	1.1041	1.1833	1.2297	1.2719	1.3102	1.3446
0.9685	1.0365	1.1003	1.1601	1.2160	1.3023	1.3540	1.4012	1.4441	1.4829
1.0600	1.1349	1.2053	1.2714	1.3332	1.4269	1.4841	1.5366	1.5844	1.6278
1.1558	1.2379	1.3152	1.3878	1.4559	1.5572	1.6202	1.6779	1.7307	1.7786
1.2556	1.3452	1.4297	1.5093	1.5839	1.6931	1.7621	1.8255	1.8834	1.9360
1.3596	1.4571	1.5491	1.6359	1.7174	1.8366	1.9119	1.9813	2.0448	2.1027
1.4678	1.5734	1.6733	1.7676	1.8564	1.9872	2.0692	2.1449	2.2144	2.2779
1.5803	1.6945	1.8026	1.9048	2.0011	2.1436	2.2327	2.3150	2.3907	2.4602
1.6990	1.8225	1.9394	2.0499	2.1540	2.3007	2.3964	2.4851	2.5669	2.6420
1.8220	1.9552	2.0812	2.2003	2.3126	2.4632	2.5659	2.6612	2.7493	2.8302
1.9481	2.0910	2.2264	2.3544	2.4751	2.6353	2.7459	2.8486	2.9436	3.0313
2.0772	2.2300	2.3748	2.5119	2.6413	2.8174	2.9367	3.0477	3.1507	3.2457
2.2103	2.3734	2.5280	2.6745	2.8129	3.0056	3.1339	3.2536	3.3647	3.4675
2.3504	2.5245	2.6896	2.8460	2.9938	3.1936	3.3306	3.4585	3.5775	3.6878
2.4946	2.6801	2.8561	3.0228	3.1802	3.3871	3.5332	3.6696	3.7968	3.9148
2.6418	2.8388	3.0258	3.2029	3.3703	3.5864	3.7417	3.8868	4.0222	4.1480
2.7918	3.0004	3.1985	3.3862	3.5639	3.7914	3.9560	4.1099	4.2535	4.3869
2.9459	3.1664	3.3759	3.5746	3.7628	4.0020	4.1762	4.3392	4.4912	4.6325
3.1070	3.3405	3.5625	3.7733	3.9730	4.2277	4.4134	4.5873	4.7497	4.9009
3.2726	3.5196	3.7546	3.9778	4.1896	4.4605	4.6583	4.8437	5.0171	5.1787
3.4413	3.7018	3.9500	4.1859	4.4098	4.6974	4.9072	5.1040	5.2883	5.4602
3.6123	3.8864	4.1477	4.3966	4.6331	4.9347	5.1562	5.3641	5.5586	5.7403
3.7873	4.0753	4.3503	4.6124	4.8619	5.1779	5.4113	5.6305	5.8357	6.0272
3.9698	4.2726	4.5620	4.8380	5.1010	5.4310	5.6771	5.9082	6.1248	6.3272
4.1569	4.4751	4.7792	5.0694	5.3461	5.6913	5.9503	6.1938	6.4222	6.6358
4.3482	4.6822	5.0016	5.3067	5.5977	5.9561	6.2283	6.4846	6.7252	6.9506
4.5440	4.8944	5.2298	5.5506	5.8569	6.2232	6.5093	6.7790	7.0328	7.2707
4.7441	5.1112	5.4631	5.7999	6.1219	6.4961	6.7965	7.0800	7.3471	7.5981
4.9452	5.3287	5.6965	6.0489	6.3862	6.7786	7.0933	7.3909	7.6716	7.9359
5.1497	5.5495	5.9334	6.3016	6.6543	7.0690	7.3987	7.7108	8.0056	8.2835

Appendix D

Board Foot Volume Table For Standing Timber

A QUICK METHOD OF ESTIMATING APPROXIMATE VOLUME OF STANDING TIMBER
(BASED ON THE ONTARIO LOG RULE, FORM CLASS #79)

Dbh in inches	MERCHANTABLE LENGTHS in feet																		
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	44	48
10	16	20	24	28	32	35	37	40	44	46	46	50	53	55	58	60	61	64	67
11	20	26	31	36	41	44	47	51	55	58	60	64	67	70	73	75	77	82	86
12	25	31	37	43	50	54	58	62	67	71	74	78	82	86	91	94	97	102	108
13	30	37	45	53	60	65	70	75	80	85	90	95	100	105	110	114	117	124	131
14	36	46	54	63	73	79	85	92	99	105	110	116	122	128	134	138	142	151	160
15	42	53	64	75	85	92	99	108	116	122	129	136	143	150	157	162	168	178	189
16	49	61	74	86	98	107	115	125	135	142	149	157	166	175	184	190	197	210	222
17	56	70	91	101	112	122	131	143	154	162	170	180	190	200	211	219	226	241	255
18	62	78	94	110	125	136	147	160	173	183	193	204	215	227	239	248	256	273	290
19	70	88	105	123	141	153	166	180	195	206	218	230	243	256	270	279	289	309	329
20	78	98	118	138	157	172	186	202	218	230	243	257	272	287	302	314	325	348	370
21	87	109	131	153	175	191	207	225	243	257	271	287	304	320	337	352	362	388	413
22	96	121	145	169	193	208	224	246	269	290	311	325	338	356	374	389	403	432	460
23	106	133	160	186	212	232	252	275	297	315	332	351	371	392	413	429	445	476	508
24	117	146	176	205	234	256	278	303	328	348	367	384	401	429	457	475	492	528	563
25	127	159	191	223	255	279	303	330	357	378	399	423	447	472	498	517	536	574	612
26	137	172	207	241	275	301	327	357	387	410	432	458	485	513	541	562	583	625	667
27	149	186	222	260	298	326	355	398	420	444	468	497	526	558	589	612	635	681	727
28	161	203	242	282	323	354	385	420	456	482	509	541	573	606	640	665	689	739	789
29	173	217	260	304	347	380	414	452	490	520	549	583	617	652	688	725	743	792	852
30	187	233	280	327	374	410	447	488	529	561	594	631	667	705	743	773	802	861	921
31	200	250	300	350	400	439	478	523	567	601	635	674	714	756	799	830	862	926	990
32	214	267	320	374	428	470	513	560	608	645	683	720	768	813	858	893	928	998	1067
33	228	284	341	399	457	502	547	598	649	688	727	773	818	869	919	955	991	1064	1140
34	243	302	365	424	487	535	584	638	692	735	777	826	875	927	978	1018	1058	1139	1220
35	257	320	385	450	515	566	617	674	732	777	822	674	925	1030	1036	1079	1122	1210	1295
36	273	341	411	478	546	601	656	717	778	827	876	931	986	1045	1103	1149	1195	1286	1379
37	280	362	435	508	580	638	696	762	828	878	929	987	1045	1110	1174	1223	1272	1372	1469
38	306	381	454	533	612	674	736	806	875	929	983	1045	1108	1176	1244	1297	1350	1457	1561
39	323	402	485	565	646	728	771	847	923	982	1040	1106	1172	1241	1311	1367	1422	1533	1643
40	340	425	511	596	681	751	821	898	975	1038	1101	1170	1240	1313	1386	1444	1508	1628	1746

Appendix E

Metric Equivalents

VOLUME (liquid)		PROPORTION		LENGTH	
fluid ounce (Imp)	= 28.412 mL	1 gal/acre	= 11.232 litres/ha	inch	= 2.54 cm
pint	= 0.568 litre	1 lb/acre	= 1.120 kg/ha	foot	= 0.3048 m
gallon	= 4.546 litres	1 lb/sq in.	= 0.0702 kg cm^2	yard	= 0.914 m
		1 bu/acre	= 0.898 hL/ha	mile	= 1.609 km
litre	= 35.2 fluid oz				
hectolitre	= 26.418 gal	1 litre/ha	= 14.24 fluid oz/ac	millimetre	= 0.039 in.
		1 kg/ha	= 14.5 oz avdp/acre	centimetre	= 0.394 in.
VOLUME (dry)		1 km/cm^2	= 14.227 lb/sq in.	decimetre	= 3.937 in.
		1 hL/ha	= 1.112 bu/acre	metre	= 3.28 ft.
cubic inch	= 16.387 cm^3	1 m^2 /ha	= 4.356 ft^2/ac	kilometre	= 0.621 mile
cubic foot	= 0.028 cm^3				
cubic yard	= 0.765 m^3	WEIGHT		AREA	
bushel	= 36.368 litres				
board foot	= 0.0024 m^3	ounce	= 28.349 g	square inch	= 6.452 cm^2
		pound	= 453.592 g	square foot	= 0.093 cm^2
cm^3	= 0.061 cu in	hundredweight		square yard	= 0.836 cm^2
m^3	= 31.338 cu ft	(Imp)	= 45.359 kg	square mile	= 2.59 km^2
hectolitre	= 2.8 bu	ton	= 0.907 tonne	acre	= 0.405 ha
m^3	= 1.308 cu yd	gram	= 0.035 oz avdp		
cord (standard)	= 3.62 m^3	kilogram	= 2.205 lb avdp	cm^2	= 0.155 sq in.
		tonne	= 1.102 short ton	m^2	= 1.196 sq yd
TEMPERATURE				km^2	= 0.386 sq mile
		ENERGY		ha	= 2.471 acres
°F = (°C x 9/5) + 32					
°C = (°F – 32) x 5/9		btu	= 1055.87 joules		

Conversion Factors

Imperial to Metric

Imperial units	Approximate conversion factor	Results in:
LINEAR		
inch	x 25	millimetre (mm)
foot	x 30	centimetre (cm)
yard	x 0.9	metre (m)
mile	x 1.6	kilometre (km)
AREA		
square inch	x 6.5	square centimetre (cm^2)
square foot	x 0.09	square metre (m^2)
acre	x 0.40	hectare (ha)
VOLUME		
cubic inch	x 16	cubic centimetre (cm^3)
cubic foot	x 28	cubic decimetre (dm^3)
cubic yard	x 0.8	cubic metre (m^3)
fluid ounce	x 28	millimetre (mL)
pint	x 0.57	litre (L)
quart	x 1.1	litre (L)
gallon	x 4.5	litre (L)
bushel	x 0.36	hectolitre (hL)
WEIGHT		
ounce	x 28	gram (g)
pound	x 0.45	kilogram (kg)
short ton (2000 lb)	x 0.9	tonne (t)

Imperial units	Approximate conversion factor	Results in
PRESSURE		
pounds per square inch	x 6.9	kilopascal (kPa)
POWER		
horsepower	x 746	watt (W)
	x 0.75	kilowatt (kW)
SPEED		
feet per second	x 0.30	metres per second (m/s)
miles per hour	x 1.6	kilometre per hour (km/hour)
AGRICULTURE		
gallons per acre	x 11.23	litres per hectare (L/ha)
quarts per acre	x 2.8	litres per hectare (L/ha)
pints per acre	x 1.4	litres per hectare (L/ha)
fluid ounces per acre	x 70	millilitres per hectare (mL/ha)
tons per acre	x 2.24	tonnes per hectare (t/ha)
pounds per acre	x 1.12	kilograms per hectare (kg/ha)
ounces per acre	x 70	grams per hectare (g/ha)
plants per acre	x 2.47	plants per hectare (plants/ha)

Appendix F

List of Ontario Ministry of Natural Resources District Offices

DISTRICT OFFICES

SOUTHERN ONTARIO

Central Region

Lindsay District
322 Kent Street West
Lindsay
Ontario K9V 4T7
Telephone (705) 324-6121

Maple District
10401 Dufferin St.
Maple
Ontario L0J 1E0
Telephone (416) 832-2761

Huronia District
Midhurst
Ontario L0L 1X0
Telephone (705) 728-2900

Cambridge District
Beaverdale Road,
P.O. Box 2186, Cambridge
Ontario N3C 2W1
Telephone (519) 658-9355

Niagara District
Box 1070, Highway No. 20
Fonthill
Ontario L0S 1E0
Telephone (416) 892-2656

Eastern Region

Carleton Place District
10 Findlay Ave.
Carleton Place
Ontario, K7C 3Z6
Telephone (613) 257-5735

Cornwall District
P.O. Box 1749, 113 Amelia St.
Cornwall
Ontario K6H 5V7
Telephone (613) 933-1774

Brockville District
P.O. Box 605, Brockville
Ontario K6V 5V8
Telephone (613) 342-8524

Tweed District
Metcalf Street
P.O. Box 70, Tweed
Ontario K0K 3J0
Telephone (613) 478-2330

Napanee District
1 Richmond Blvd.
Napanee
Ontario K7R 3S3
Telephone (613) 354-2173

Southwestern Region

Simcoe District
P.O. Box 706
Hwy 3, 548 Queensway W.
Simcoe,
Ontario
N3Y 4T2
Telephone (519) 426-7650

Aylmer District
353 Talbot St. West
P.O. Box 940, Aylmer
Ontario N5H 2S8
Telephone (519) 773-9241

Chatham District
Box 1168, 435 Grand Ave. W.
Chatham
Ontario N7M 5L8
Telephone (519) 354-7340

Wingham District
R.R. 5 Wingham
Ontario N0G 2W0
Telephone (519) 357-3131

Owen Sound District
611 Ninth Ave. East
Owen Sound
Ontario
N4K 3E4
Telephone (519) 376-3860

Algonquin Region

Parry Sound District
4 Miller Street 2nd floor
Parry Sound
Ontario P2A 1S8
Telephone (705) 746-4201

Bracebridge District
Box 1138,
Bracebridge
Ontario P0B 1C0
Telephone (705) 645-8747

Algonquin Park District
Box 219, Whitney
Ontario K0J 2M0
Telephone (613) 637-2780

Minden District
Minden
Ontario
K0M 2K0
Telephone (705) 286-1521

Bancroft District
P.O. Box 500, Bancroft
Ontario K0L 1C0 Hwy 28
Telephone (613) 332-3940

Pembroke District
Riverside Drive
P.O. Box 220, Pembroke
Ontario K8A 6X4
Telephone (613) 732-3661

NORTHERN ONTARIO

Northern Region

Hearst District
P.O. Box 670, 631 Front St.
Hearst, Ontario P0L 1N0
Telephone (705) 362-4346

Kapuskasing District
6-8-10 Government Road
Kapuskasing
Ontario P5N 2W4
Telephone (705) 335-6191

Moosonee District
P.O. Box 190, Moosonee
Ontario P0L 1Y0
Telephone (705) 336-2987

Cochrane District
2 Third Avenue
P.O. Box 730, Cochrane
Ontario P0L 1C0
Telephone (705) 272-4365

Kirkland Lake District
P.O. Box 129, Swastika
Ontario P0K 1T0
Telephone (705) 642-3222

Timmins District
896 Riverside Drive
Timmins
Ontario P4N 3W2
Telephone (705) 267-7951

Gogama District
Gogama P.O. Box 129
Ontario P0M 1W0
Telephone (705) 894-2000

Chapleau District
34 Birch Street
Chapleau
Ontario P0M 1K0
Telephone (705) 864-1710

North Central Region

Atikokan District
Atikokan, 108 Saturn Ave.
Ontario P0T 1C0
Telephone (807) 597-6971

Thunder Bay District
Box 5000, 435 James St. S.
Thunder Bay
Ontario P7C 5G6
Telephone (807) 475-1511

Nipigon District
P.O. Box 970, Nipigon
Ontario P0T 2J0
Telephone (807) 887-2120

Geraldton District
208 Beamish Ave. W.
P.O. Box 640, Geraldton
Ontario P0T 1M0
Telephone (807) 854-1030

Terrace Bay District
Box 280, Terrace Bay
Ontario P0T 2W0
Telephone (807) 825-3205

Northeastern Region

Wawa District
22 Mission Rd.
P.O. Box 1160, Wawa
Ontario P0S 1K0
Telephone (705) 856-2396

Sault Ste. Marie District
875 Queen St. E.
Sault Ste. Marie
Ontario P6A 5L5
Telephone (705) 949-1231

Blind River District
62 Queen Street
P.O. Box 190
Blind River
Ontario P0R 1B0
Telephone (705) 356-2234

Espanola District
P.O. Box 1340
148 Fleming St., Espanola
Ontario P0P 1C0
Telephone (705) 869-1330

Sudbury District
Highway 69 South
Provincial Government Road
Box 3500, St. "A", Sudbury
Ontario P3A 4S2
Telephone (705) 522-7823

Temagami District
P.O. Box 38, Temagami
Ontario P0H 2H0
Telephone (705) 569-3622

North Bay District
P.O. Box 3070, R.R.3 North Bay
Ontario P1B 8K7
Telephone (705) 474-5550

Northwestern Region

Red Lake District
P.O. Box 323, Highway 105
Red lake
Ontario P0V 2M0
Telephone (807) 727-2531

Kenora District
808 Robertson Street
P.O. Box 5080, Kenora
Ontario P9N 3X9
Telephone (807) 468-9841

Dryden District
479 Government Rd.
P.O. Box 730, Dryden
Ontario P8N 2Z4
Telephone (807) 223-3341

Sioux Lookout District
P.O. Box 309 Prince St.
Sioux Lookout
Ontario P0V 2T0
Telephone (807) 737-1140

Fort Frances District
922 Scott Street
Fort Frances
Ontario P9A 1J4
Telephone (807) 274-5337

Ignace District
P.O. Box 448
Ignace
Ontario P0T 1T0
Telephone (807) 934-2233